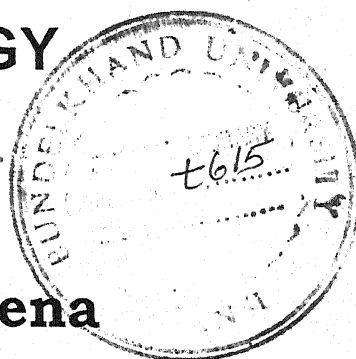**STUDIES ON THE EFFECT OF INSECT GROWTH REGULATORS ON THE GROWTH AND DEVELOPMENT OF PERICALLIA RICINI F. (LEPIDOPTERA : ARCTIIDAE)**

A THESIS

SUBMITTED TO

BUNDELKHAND UNIVERSITY

JHANSI

FOR THE DEGREE OF

DOCTOR OF PHILOSOPHY

IN

ZOOLOGY

By

Amit Saxena

Under the supervision of

DR. PRABHAT KUMAR

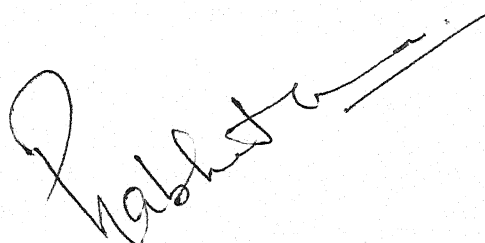DEPT. OF ZOOLOGY

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C E R T I F I C A T E

It is certified that the present thesis entitled, "STUDIES ON THE EFFECT OF INSECT GROWTH REGULATORS ON THE GROWTH AND DEVELOPMENT OF *PERICALLIA RICINI F.* (Lepidoptera : Arctiidae) by *SRI AMIT SAXENA*, embodies the findings of his original research work carried out under my supervision within prescribed period and it fulfils all requirements for the award of the Ph.D. Degree of Bundelkhand University, Jhansi, U.P.

28TH FEB., 2002

(DR. PRABHAT KUMAR)

SUPERVISOR,

ACKNOWLEDGEMENT

Amit Soveva

Date: 28TH Feb.2002   (AMIT SAXENA)

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Chapter - 1

Introduction

INTRODUCTION

The wooly bear, *Pericallia ricini* Fabricius (**Lepidoptera : Arctiidae**) is a polyphagous insect feeds on Soyabean, Groundnut, Castor, Cucurbits, (**Lefroy, 1909; Ayyar, 1940, Rawat and Singh; 1979**), Banana, Gingelly, Cotton, Agasthi, Calotropis, Morgina, Oleander, Colocasia (**Fletcher, 1914**), Dub (**Kushwaha et. al., 1964**), Zenia, Balasm, (**Jain et al., 1971**), Sweet Potato (**Nayyer et al., 1971**), Sunflower (**Ayyanna et al., 1978**) and **Raja Mohan, Krishnan and Subramanyan (1974)** Boungainvillea (**Raghunatth et al., 1981**) and Brinjal (**Ranjith and Dale, 1985**). **Kundu (1983)** reported *Pericallia ricini* as a major pest of kharif crop particularly in Gujarat and Rajasthan. **Nair (1978)** recoginsed *P. ricini* as a major insect pest of Kerala state. It's biology and development on different food plants described by **Ayyanna et al., (1978), Basu (1944), Jain et al., (1971), Kushwaha et al., (1964), Perumal (1972), Srivastava (1984), Thakur** and **Pillai (1984).** *Pericallia ricini* is reported from India, Pakistan, Sri Lanka, Bangladesh, Europe, Africa and several other parts of globe. It causes great loss to above mentioned plants. These plants have great economic value. Its menace has increased in different parts of Uttar Pradesh especially in Lucknow, Allahabad and Bundelkhand regions. Due to infestation partly or

sometimes complete defoliation takes place (**Ayyanna *et al.*, 1978**), so that loss due to its severe infestation is worth crores every year.

About fifteen years ago, *Pericillia ricini* was considered to be a mild pest, usually under control. But during last seven years, its ravage has increased; it appears on host plants in a very large number year after year inspite of frequent use of recommended insecticides against it. In 1992, the castor and sweet potato crop in Kanpur, Jhansi and Jalaun districts were recorded very heavy infestation of this pest, leaving farmers, helpless. During this out break, farmers used common insecticides against this pest but instead of being cut down, its menace has increased and has been increasing. This indicated that the pest has become resistant to those common insecticides and has been breeding resistant populations. Therefore, this pest needs attentions and an effective control against this pest is most desirable.

(With the discovery of synthetic insecticides in 1940s, which was refered to as first generation insecticide, it was believed that the pest population will easily eliminated). **Srivastava and Awasthi (1961)** has tried some strong insecticides against arctids but older larvae have survived the toxicity of these insecticides. This demands use of still stronger insecticides against this pest.

Economic entomologists had made good efforts in search of such chemicals and consequently they have been successful in tracing a good number of chemicals to be employed as alternative control strategy against this pest. **Sundramurthi and Abdul Kareem (1968), Tilak (1978), Rajendran and**

Gopalan (1979), **Dale, Sardamma** and **Chandrika (1978), Dale** and **Sardamma (1981), Dhandapant, Raja Mohan** and **Kareem (1985)** studied the effect of fractions of root, stem and leaf of Neem, *Calamus garlic, Datura stramonium* and *Ocimum sanctum*. Extracts obtained from above mentioned plants caused 50 to 100 percent mortality and prolonged the larval development and also caused very poor larval and pupal growth.

Later these plant insecticides obtained from different plants proved ineffective. This also indicated that the pest has become resistant to these botanical insecticides. The fecundity of the surviving adults avoiding sublethal dosage is also increased **(Knutson, 1951 and Afifi** and **Knutson, 1956)**. This situation demanded the use chemical insecticides to which the insect has developed resistance because the application of such insecticides has given spectacular results and regard to the control some abnoxious pests. **Rawat** and **Singh (1979), Mathai** and **Nair (1979), Rawat** and **Singh (1980), Pandey, Prasad, Srivastava, Tiwari** and **Mathur (1980)** applied different insecticides to control this pest.

When these chemicals applied carelessly, they damage ecological conditions. These chemical insecticides may result in acute and long terms effects including sickness and death of people, useful animals and destruction of crops. Even when properly used, they may cause harmful effects on man's health and well beings. Such problems forced the economic entomologists to proceed further in search of safer insecticides to control the different crop pests.

Economic entomologists had made efforts in search of such chemicals and consequently they have been successful in tracing a good number of chemicals to be employed as alternative control strategy against this pest. They use chemosterilants, juvenile harmones, pheromones etc. as well as their analogs and repellents. **Pandey (1976); Dhawan (1991)** found chemosterilants (Tepa, Metepa, Thiotepa etc.) were effective to control this polyphagous pest. According to findings of these workers chemosterilants fit well in decreasing the population of *P.ricini* below the economic threshold by reducing their birth rates than by increasing their death rates. But they involved very much cost as compared to other insecticides and desired success could not be achieved.

The insect growth regulator, a fourth generation insecticide, accidently came in the existence in the Laboratory of Philips, Duphar, The Netherlands, while preparing the herbicides. First insect growth regulator synthesized, was diflubenzuron, which from Benzoyl phenyl urea group. Later, different groups of insect growth regulators, having chitin biosynthesis inhibiting property, were indentified. The different groups of insect growth regulators, though differ in their chemical structure and mode of action, but have a common characteristic, i.e., they exhibit lethal action in juvenile stages and sterility in sexually mature adults, thus the pest population declines very rapidly. Besides, they also inhibit the food consumption and growth of individuals, which survive sublethal treatments. This becomes an additional benefit in the field of pest management as surviving pest will consume less food, causing least injury to agro-ecosystem. The supperssion

of pest population by the use of insect growth regulators has already been achieved by many workers. (**Flint** *et. al.*, **1978; Zepp** *et. al.*, **1979; Hopkins** *et. al.*, **1982; Velcheva 1983; Lecheva 1985; Sharma 1993; Moraschini, 1998)** etc.

The bioefficacy of insect growth regulators is generally manifested during ecdysis as it disturbs the process of chitin deposition, thus effecting growth and development of the insects. It also results in failure to feed, due to displacement of mandibles, maxillae and labrum and blockage of the gut. These insect growth regulators also produce delayed symptoms, in which the adults fail to escape from pupal skin and therefore can not fly, feed and mate. These insecticides also induce the fertility and fecundity as observed by many entomologists.

Several insect growth regulators have been found effective in suppressing the population of *Euproctis icilia, Euproctis fraterna, Musca domestica, Pieris brassicae, Spodoptera litura, Pectinophora gossypiella, Earias insulana, Leptinotarsa decemilinata, Achoea janta, Oxya japonica, Tenebrio monitor, Utetheisa pulchella* and many other insects.

These chemicals particularly penfluron, diflubenzuron, diamino fruly-S-triazine, diofenolan, cyromazine, esaflumuron, novaluron, keyouniao, buprofezin, triflumuron, fenoxycarb, tebufenozide, teflubenzuron, lufenuron and fenoxiculve have been found effective without any obvious effect mating ability and life span of the insect. The possible use of insect growth regulators present an intriguing and exciting area for research. In view of already proved efficacy of insect growth

regulators as control measure in good number of insects and the notority of *Pericallia ricini* it was thought desirable to apply these chemicals against this pest hence this investigation. The work embodies the results relating to four insecticides (insect growth regulators) with reference to their effects on growth, development, longevity and reproduction of *P. ricini*

Chapter - II

Review of Literature

REVIEW OF LITERATURE

The benzoyl phenyl urea, a chitin biosynthesis inhibitor was first synthesized in early 1970s, at **Phillips Duphar,** The Netherlands. This chemical was accidently discovered by the investigators while preparing and examining the derivatives of herbicides dichlobenil and fenuron **(van Daalen et. al., 1972)**. These derivatives showed insecticidal properties. The action of these derivatives was limited to moulting process, as the chemical interfered with cuticle deposition. This discovery led further in the bioassay of different groups of chemicals having chitin biosynthesis inhibiting property.

Mulder and **Gijswijt (1973)** and **Wellinga, Mulder** and **van Daalen (1973)** reported the discovery of two new promising insecticides of Benzoyl phenyl urea group which brought about the formation of defective cuticle by interfering with biosynthesis of chitin. These chemicals were synthesized in the laboratory of **Philips Duphar,** The Netherlands.

Cupp and **O'neal (1973)** for the first time reported the morphogenetic effect of juvenile hormone analogue (ZR-512 and ZR-515) on larvae *Solenophsis richteri* (Forel) and *S. invicta* (Buren). This chemical was capable of preventing pupation and proved consistently effective when administered topically and orally.

Post and Vincent (1973) found that benzoyl phenyl urea group restricts growth of the insect and do not cause direct larval intoxication. However, mortality occurs at a post treatment moult, in the larval or pupal stage at lower concentration.

According to Wright (1974) the insect growth regulator [N-(4-chlorophenyl)-N-(2,6-diflurobenzoyl)-Urea] prevents the emergence of *Musca domestica* L., and *Stomoxys calcitrons* (L) when applied topically at a rate of 1 mg/ft^2 at breeding surface area in a cattle feed plot and at a waste water treatment plant observed 90% control of house flies. This chemical cause a disruption in the cuticle formation of the house fly during larval-pupal metamorphosis.

Post and Mulder (1974) gave the insecticidal property and mode of action of benzoyl phenyl urea group against *Pieris brassicae* L. The resulting effect of these was the reduction or suppression of the insect population.

Bijloo (1975) reported, that after ingestion of diflubenzuron, larvae of lepidoptera, coleoptera and diptera were usually unable to complete their next moult properly and died either from cuticle rupture or from starvation.

El-Guindy and Bishara (1975) reported the effects of R-20458, a juvenile hormone analogue on the reproductive biology of the cotton bollworm, *Heliothis armigera* Hubn. The results revealed that the topical treatment of the 6th instar larvae, prepupae and pupae with juvenoids did not seriously affect percentage of pupation and adult emergence. On the other hand all the J.H. analogues, when tested on the same stage showed high potential as chemosterilants.

Wright (1975) reported that development of *Musca domestica* L. was inhibited when they were fed on the faecal matter of cattle which contained 0.1 and 0.5% of the insect growth regulator TH 60-40 [N-(4-chlorophenyl)-N-(2,6-diflurobenzoyl)-Urea]. The application of TH 60-40 or a mixture of 21.4% stirofas and 5.3% richlorvas (Ravop) as area treatment to larval breeding site (0.05 and 0.75% conc. respectively) inhibited adult emergence throughtout the fly breeding season.

Bobaye and **Carman (1975)** observed that five insect growth regulators (juvenile hormones) activity when tested against the first instar of *Aonidiella auranti* (Maskell), responded in varying degree at all concentrations, resulting in the arrestation of development at certain stage. Most of tested chemicals and in particular methropene (iso parayle CEE)- 11-methoxy 3,7,11 trimethyl –2-4-dodecadienota) were more effective in inhibiting metamorphosis of the males than that of the females particularly at lower concentration. Substantial response to the compounds was elicited at higher concentration. At the highest concentration level, 100% inhibition of male and female development was achieved with all the chemicals.

Mc Gregor and **Kramer (1976)** studied the activity of Dimilin against coleoptera in stored wheat and corn. In a laboratory test when 1 to 10 ppm solution of diflubenzuron was applied to wheat or corn, the development of progeny of rice weevil *Sitophilus oryzae* (L), granary weevil, *S. granarius* (L), maize weevil, *S. zeamaiz* Motschulsky, lesser grain borer, *Rhizopertha dominica*

(F), confused flour beetle, *Tribolium confusum* Jacquelinduval and saw toothed grain beetle, *Oryzaephilus surinamensis* (L) was prevented. After pre exposure of the adults to 10 ppm, no progeny of rice weevil, granary weevil and lesser grain borer developed.

Tamaki (1976) evaluated PH 60-40 against Colorado potato beetle *Leptinotarsa decemlineata* (Say) and the Zebra caterpillar *Ceramica picta* Harris, to determine the effect of this compound on the feeding behaviour and concluded that higher the rate of PH 60-40, the less leaf tissue was consumed. Small larvae feeding on plants treated at 500, 250 and 125 ppm consumed 95, 88 and 26% less tissue respectively. This was in addition to disorienting the insect and causing them to fall from the plants. Thus PH 60-40 suppressed feeding activity of those insects remaining on plant.

Urs and **Narasimhan (1977)** studied the effect of R-20458 on the growth and development of tobacco caterpillar, *Spodoptera litura* and reported that when 5th instar caterpillars were topically treated on the last abdominal segment with various doses, the lower dosages produced malformed pupa or larva-pupa intermediate and higher dosages resulted in super numerary larvae with sluggish activity and practically nonfeeding characters, leading to the death of the insect.

Flint and **Smith (1977)** also observed the first instar larvae and adult *Pectinophora gossypiella* (Saunders) by giving (**Thompson-Hayward**) TH 60-40 [N-(4-chlorophenyl)-N-(2,6 diflurobenzoyl)- Urea] in either diets or on treated surfaces. Reduction in emergence by 64% from control levels was observed on 1

ppm in larvae diet and greater doses greatly reduced larval development. However, exposure of first instar for 24 h to 9 bait formulation, containing 10,000 ppm of Th 60-40 on cotton leaves brought down the number of larvae surviving to 5th stage by 25%. Continuous exposure of adults of TH 60-40 either in diet or on treated surface caused a gradual loss of fertility during a 4 to 6 days period.

Calkins, Hill, Hue Hel and **Mitchell (1977)** worked on the egg viability and larval development of Herbst. When adults were fed diflubenzuron, the effects were not long lasting. The diflubenzuron did not affect the fecundity much. It did affect the development of the larvae inside the fruit severely during egg, stage or at moulting. When 0.25% granules of diflubenzuron was added to soil at the rate of 358 ppm., no emergence of adult was observed. This showed that diflubenzuron did not breakdown in the environment and its activity persisted. In another test diflubenzuron was mixed with unsterilized soil at the rate of 108, 54, 35, 21.74, 5.43, 4.34, 2.17 or 1.09 ppm to see that minimum amount of material needed for adverse effect on pupation and eclosion. The data so obtained showed that LD 50 was calculated 0.14 ppm. So very low doses can cause high mortality rate.

Sundaramurthy and **Balasubramanian (1978)** studied the effect of Dimlin on tobacco caterpillar, *Spodoptera litura* under induced hyper hormone condition and came to the conclusion that when 6th instar larvae of *S. litura* were treated with 1 ug Dimilin, caused 99.60% inhibition of pupal formation and the phenyl urea under hyper hormone condition resulted in high degree of inhibition

by producing more larval-pupal deformities and inhibited the completion of moulting in super larvae.

Abid, Ghobrial, El Haideri and Abbs (1978) reported the effect of dimilin on 3rd instar larvae of spiny boll worm *Earias insulana* Boised. in the laboratory. After treating the larvae, it was observed that the moulting could not be completed normally, because of the inability in completely shedding of the exuvia. Other abnormalities in mouth parts, thoracic region and abdominal region were also seen, leading to the death of the insect. Affected larvae lived from 4 to 5 days of post treatment and severly deformed individuals frequently died within 3 days and when 12.5 mg/larva was applied, it was seen that 42.5% of the larvae died within 7 days.

Abo-Elghar, Radwan and Ammar (1978) observed on the morphogenetic activity of an IGR compound PH 60-40 on newly formed *Spodoptera littoralis* pupae treated topically and concluded that newly formed pupae of *S. littoralis* were highly sensitive to the PH 60-40, when it was applied topically. It was evident that actual graduation in the morphogenesis effect increased with increased dosages. The PH 60-40 showed its action at 0.05% as all emerged moths were either deformed or dead.

Ascher, Wysoki, Nemny and Gur-Telzak (1978) observed that the aqueous diflubenzuron suspension was moderately toxic to *Boarmia selenaria* larvae for contact treatment and the topical application against large larvae. He

also observed that small larvae of *B. selenaria* fed for 4 days on the suspension dipped lucerns leaves suffered from severe developmental disturbances.

Flint, Smith, Noble, Shaw, DeMilo and **Khalil (1978)** evaluated that diflubenzuron (N[[(4-chlorophenyl) amino] carbonyl)]-2,6 diflubenzamide) [AB-29054]; EL – 494 (N[[[5-(4-bromophenyl)-6-methyl-2-pyrozinyl] amino] carbonyl] –2,6-dichlorobenzamide); EL-588 (2,6-dichloro-N[[[5-(4-chlorpheyl)-2-pyrozinyl] amino] carbonyl] benzamide), Al_3 63220 (N-[[(4-bromophenyl) amino] carbonyl]; 2,6-diflurobenzamide) and Al_3 63223 (2,6-difluuro –N-[[[4-(trifluromethyl phenyl] amino] carbonyl] benzamide] prevented development of adult pink boll worm *Pectinophora gossypiella* (Saunders), when they were fed on larval diet at 1-10 ppm. Contact experiments with adult moths indicated little activity upto 18 mg/cm^2 except for AI_3 63220 & AI_3 63223 which caused significant mortality after one week exposure to treated cage surface. Diflubenzuron and EL –494 were tested for systemic activity by treating foliage of cotton plants at the rates upto 15.2 mg/plant without effect on subsequent development of the pink boll worm. A further test in field cages using 2 compounds at a rate of 0.11 kg/ha indicated that diflubenzuron was superior to EL-494 for control of the cotton leaf perforator *Bucculatrix thruberiella* Busck, but either compound had only activity against the pink boll worm.

Grosscurt (1979) investigated the larvicidal and ovicidal mode of action of diflubenzuron. On larvae, it acts as stomach poison but some times exhibits contact activity. All instars can be controlled but older instar are generally less

susceptible than younger ones. He also reported, after exposure of *Leptinotarsa decemlineata* larvae, distortion in newly deposited cuticular layer, ovicidal effect resulted from direct contact of diflubenzuron with eggs or from contamination of females by contact or feeding.

Reed and **Boss (1979)** studied the effect of diflubenzuron on food consumption by the soyabeen looper and came to the conclusion that food consumption of treated 5th instar larva was less than that of untreated larvae over equal units of time, regardless of the length of survival time.

Nateson and **Balasubramanian (1980)** studied the effect of diflubenzuron on pupae of *Spodoptera litura* (F) and found that when the pupae of different ages were dipped in different concentrations of diflubenzuron solution for 10 seconds, caused pupal mortality, partial emergence and malformed adults. The susceptibility of pupae decreased with increase in their age.

Chattoraj and **Dwivedi (1980)** reported the toxic effect of penfluron on *S. litura* and found that when the chemical was applied topically at 0.0015, 0.15, 0.30 or 0.45/ ug/ larvae to final instar larvae, mortality averaged 68, 84, 90 and 100% respectively as compared with 10% for no treatment. They also observed 100% sterility with the lower doses of penfluron i.e. 0.0045/ug/larva. Penfluron was more active on males than females.

Wright, Roberson and **Dawson (1980)** studied the effect of diflubenzuron on sperm transfer, mortality and sterility when given to adults of *Anthonomous grandis* (Boheman). On the basis of mortality, sterility and transfer

of sperm, a level of either 50 or 100 ppm diflubenzuron given in diet for 5 days plus irradiation with 10 krad of gamma irradiation on the 6th day, produced sterile male and female boll weevils. Higher level of diflubenzuron reduced sperm transfer. The feeding of diflubenzuron in the adult diet did not contribute to adult mortality but significantly lowered egg hatching & larval development.

Mitsui *et al.* **(1980)** found that when diflubenzuron was applied topically or orally to the final instar of *Munduca* larvae, the cuticle production was inhibited. After topical application of 5 μg diflubenzuron to the newly moulted 5th instar larvae, the rate of cuticle deposition decreased to two-third of normal thickness. It inhibited both endocuticle deposition and ecdysterone initiated pupal cuticle synthesis by the epidermis. Both effects were due to inhibition of glucose or glucosamine incorporation into chitin.

Mitsui, Nobusawa and **Fukami (1981)** studied the effect of diflubenzuron on chitin synthesis and chitin synthetase activity during the last larval instar of *Mamestra brassicae* (L.). In vivo, the compound inhibited chitinous cuticle formation. It appears that diflubenzuron blocks the terminal polymerisation step in chitin synthesis.

Madrid and **Stewart (1981)** studied the impact of diflubenzuron spray on gypsy moth paratoids in the field. It was observed that diflubenzuron for control of *Lymantria dispar* (L). was applied once at 0.03 kg. a.i. in 4.76 litre water/ha. Larval mortality of *L. dispar* was high, about 50% after 1 week and 100%

after 10 days. *Apanteles melanscelus* (Ratz.) mortality was about 80% after 2 weeks, Tachinids showed 100% mortality.

Abdelmonem and **Mumma (1981)** studied the comparative toxicity of some moult inhibiting insecticides to the gypsy moth, *Lymantria dispar* (L.). Third and fifth-instar larvae were fed on diet containing various concentrations (0.06 to 0.8 ppm) on the moulting-inhibiting compounds. The larvae scored for moulting abnormalites. EC 50s value for diflubenzuron for failure of 3rd instar to moult to the fourth were 0.176, 0.513 and 0.052 ppm, and for failure to moult to the fifth instar were 0.075, 0.175 and 0.009 ppm, respectively. EC 50s for the failure of fifth instars to moult to pupae (males) or to the sixth instar (females) were 0.094, 0.531 and 0.122 ppm, respectively. Continuous feeding of third instars until pupal formation on diet containing diflubenzuron resulted in the lower EC 50s of 0.009 and 0.006 ppm respectively. Diflubenzuron was most toxic to third instars. They also noted that some larvae appeared to moult normally but failed to eat resulting in their death.

Ascher and **Eliyahu (1981)** investigated the residual contact toxicity of triflumuron (BAY SIR-8514) a chitin synthesis inhibitor, on *S. littoralis* larvae in the laboratory. The larvae were confined on the treated glass for 90 min and subsequently kept on lucerne foliage. The ED 50 for cumulative mortality upto the adult was 0.0017 g/m^2 for larvae weighing 100 mg and 0.004 g/m^2 for those weighing 200 mg. when administered in this way, the toxicity of triflumuron was considerably greater than diflubenzuron.

Rabindra and **Balasubramanian** **(1981)** studied the effect of diflubenzuron on the castor semilooper, *Achoea janata* Linn. It was noted that the lowest concentration tested (0.05 g/litre) inhibited moulting and caused 96% mortality, while concentration of 1.0g/litre caused 100% mortality. Various morphological deformities were also observed in pupa from treated larvae.

Segistan, *et. al.* **(1982)** studied the effect of diflubenzuron on the reproduction and larval development of *S. frugiperda*. The larvae of different instars (1st, 3rd, 5th & 6th) were confined for 48h with maize leaves previously dipped in 0.0625-2 ppm, diflubenzuron. The larvae were most susceptible 10 days after hatching (in the 5th instar) at which time food consumption was greatest. Mortality at moulting was higher among larvae on treated than on untreated leaves (only 12.66% of the larvae exposed to the compound in the 5th instar completed their development to the adult stage); and the compound caused growth deformities and abnormalities. Workers found that the compound caused complete sterility in the males and partial sterility in females developing from these larvae. Both fecundity and fertility were reduced by the compound.

Lim and **Lee** **(1982)** studied the toxicity of diflubenzuron on *Oxya japonica* (Willemse) and its effect on moulting. A laboratory evaluation of the acute toxicity of diflubenzuron against the final stage of *Oxya japonica* nymphs showed that it was more effective in preventing the development of the nymphs into the adults when applied topically, than injected. Histological studies also revealed that treated nymphs subsequently died before or during ecdysis suffered

from severe endocuticular lesions, although these nymphs appeared normal externally.

Moffitt, Mantey and **Tamaki (1983)** reported the effect of TH-60-43, TH-60-44 penfluron and diflubenzuron on oviposition by treating adults and on subsequent egg hatch of the codling moth, *Cydia pomenella*. They found that TH-60-44 was most effective in reducing the hatching of eggs from treated adults. With TH-60-43 and penfluron, egg hatch was reduced only when the female of each mating pair was treated. Topical application of diflubenzuron to adults moderately reduce egg hatch and also reduced oviposition by females. None of these compounds adversely affected mortality, life span or mating propensity of adults.

Velcheva (1983) studied the insecticidal activity of diflubenzuron against larvae of the cabbage moth, *Mamestra brassicae*, in laboratory and field tests at concentrations of 25, 37.5, 75, 250, 375 and 750 ppm. In the laboratory, 100% larval mortality occurred on the 4th day after treatment with 750 ppm, on 7th day with 75, or 375 ppm, on the 8th day with 250 ppm and on the 10th day with 37.5 or 25 ppm. In the field test they observed 100% mortality of the 3rd instar larvae 7 days after application of the compound at 750 ppm. It was also seen that 20 days after application larval mortality had fallen to 58.62% and the surviving larvae pupated normally and had no visible morphological abnormalities.

Knapp and **Herald (1983)** evaluated the effect of two other chitin synthesis inhibitors BAY SIR-8514 and Penfluron on egg eclosion and F_1 larval

development of the face-fly by exposure of adult files to treated surface and concluded that inhibition of egg hatch and F_1 larval mortality were dependent on exposure time, concentration, mating regime and elapsed time after exposure.

Chockalingam, and **Krishnan (1984)** determined the effect of oral administration of sublethal doses of diflubenzuron on the energy budget of 5th instar larvae of *Ergolis merione* in the laboratory. The LD 50s for larvae treated for 24, 48, 72 and 96h were 52.56, 27.76, 13,60 and 8.76 / ug/larva, respectively. Treatment with the highest sublethal does (3.4 ug/larva) reduced the food consumption rate by 33.34%, the assimilation rate by 21.82% and the conversion rate by 65.64%. Diflubenzuron administered with the food not only reduced larval growth but also affected the growth and emergence of adults, causing morphological abnormalities.

Soltani (1984) reported that when diflubenzuron fed to adults of *Tenebrio molitor*, reduced the longevity and weight of the adults and the thickness of the post ecdysial adult cuticle. It also affected the production of the peritrophic membrane. The loss of weight and the decrease of longevity of the treated adults may have been because of alterations to the peritrophic membrane caused by the inhibition of chitin biosynthesis by diflubenzuron.

Swamy and **Punnaiah (1984)** determined the toxicity of sprays of triflumuron (SIR – 8514) to eggs, 3rd instar larvae and pupae of the polyphagous pest, *Spodoptera litura*. (F). They observed that direct application at 0.065% completely inhibited egg hatch. Direct application at 0.0325% and

indirect application (by feeding) at 0.065% gave complete mortality of the 3rd instar larvae, while direct and indirect application at 0.13% gave complete mortality of last instar larvae. All treated pupae completed their development, though some of the subsequent adults were malformed with treatments at higher concentration.

Soltani, Besson and **Delachambre (1984)** reported that application of diflubenzuron on newly emerged pupae of *Tenebrio molitor* (L) dipped, in it, disturbs the pupae and adult development. Four main types of treated insects were obtained according to the external morphology; blocked pupae, adult unable to ecdysed. The proportion of the four types varied with the time of treatment during the pupal life, when diflubenzuron was administered at 10g/litre concentration to the newly emerged pupae.

Abdel, Negm, Saleh (1985) evaluated the effect of the insect growth regulators, methoprene, diflubenzuron and triflumuron SIR – 8514 on 5th instar larvae and 5 day old pupae of the Egyptian cotton leaf worm, *S. littoralis* (Boisd). The larvae were fed for 24h on castor leaves which had been immersed in various concentration of the insect growth regulators for approximately 15 seconds and 5-days old pupae were treated by dipping. Symptoms of larval treatment included a retention of larval characters in the pupal stage, inhibited adult emergence and production of an additional larval instar. Treatment at both the larval and pupal stages resulted in reduced fecundity and egg hatch and increased sterility in the adult. Diflubenzuron was the most potent sterilant.

Tiwari (1985) studied the effect of dimilin on the consumption and utilization of dry matter and dietary constitution of castor, *Ricini communis* Linn. by the castor semilooper, *Achoea janata*. It was seen that there was no difference between treated and untreated adults with regard to consumption index growth rate, approximate digestibility, efficiency of conversion of ingested food (ECI), efficiency of conversion of digested food (ECD) or utilization of nitrogen. Treated insects had a greater lipid balance than untreated ones. The value of ECI and ECD in relation to conversion of food lipid and of carbohydrate were greater in untreated than for treated insects.

Lecheva (1985) studied the biological action of diflubenzuron. When this chemical was applied under laboratory and controlled field condition at 0.08, 0.1 and 0.12% on larvae of *Operophtera brumeta* and *Erannis bajaria*, the mortality rate of the treated 2nd instar larvae was 76.8% while that of 3rd and 4th instar larvae was 50.60%. The effect of the compound on the physiological process of the insects increased and was greatest shortly before the pupal stage, as a result of which, only abnormal pupae were obtained, which died. In the field, the compound was most effective, when applied to apple trees flowering and larvae were in the 2nd and 3rd instar.

El-Sayed (1985) reported the effect of diflubenzuron on larvae and adults of *Spodoptera littoralis (Boisd)*. The LC50 of diflubenzuron for 4th instar larvae exposed to treaed leaves for 24h and 48h, were 0.004 and 0.0006%, respectively. Fourth instar larvae surviving treatment with diflubenzuron had reduced larval

and subsequent population and adult emergence. Such effects were in proportion to the period of exposure to treated larvae and the concentrations used.

Radwan et al (1986) reported that the 4th instar larvae of *Spodoptera littoralis* were fed on castor and bean leaves treated with the chitin-biosynthesis disrupting agents, diflubenzuron and its analogue, SIR-8514 (triflumuron). There was a reduction in the consumption of food. Considerable decrease in growth rate was also recorded. The efficiency of converting ingested and digested food into the body substance also showed an obvious reduction, especially in the larvae, fed on diflubenzuron treated leaves.

Rao, Kumaraswamy and Balasubramanian (1987) studied the effect of dimilin on the feeding behaviour of *Cnaphalocrosis medinalis*, after ingestion or topical application or dipping larvae in diflubenzuron, at 1,50, 100, 150, 200, 250 and 500 ppm. Feeding by larvae was reduced, following treatment with 1ppm but was stimulated by concentration upto 100 ppm and then decreased, bringing about variation in values of ID50 (50%, inhibition dose). Ingestion and topical application of diflubenzuron to 2nd and 3rd instar larvae, resulted in less than 50% inhibition even at 500 ppm. For 4th and 5th instar larvae, the lowest ID 50s were recorded with the larvae dip method (204.2 and 77.6 ppm, respectively, and the highest value with the ingestion method 426.6 and 169.8 ppm, respectively).

Raja et. al. (1987) reported the effect of methoprene on the sequestration of haemolymph proteins by the fat bodies of *Chilo partellus*. In the laboratory, newly ecdysed 5th instar larvae were treated topically with 1 /µl of 2, 1.5 or 1 ppm

methoprene. Treatment at all 3 concentrations resulted in the larval-pupal intermediates and supernumerary larvae. This morphogenetic effect was accompanied by inhibition of the uptake of storage protein by the fat bodies.

Srivastava and **Khan (1988)** reported that penfluron was highly toxic to the larvae of *Pericallia ricini* (Fabr.). Complete larval mortality was recorded at $0.028/ug/cm^2$, residual level, though the prepupal formation took place in some of the treated larvae at this level. A residual deposit of 2.8% $\mu g/cm.^2$ incompletely inhibited even prepupal formation. At high residual deposit, no deformity was seen, instead high or complete lethal action was observed. The reason for the deformity at lower concentration may be due to inhibiting property of penfluron in biosynthesis of chitin. At higher concentration the chitin deposition was completely checked showing complete lethal action of the chemical. However, at lower concertation the chitin deposition was partially disturbed restricting the larva to moult into pupa, producing larva-pupa intermediate.

Khan and **Srivastava (1988)** reported that when the last instar larvae of *P. ricini* (Fabr.) treated with different concentrations of penfluron, complete larval mortality was recorded at 0.01% level. The prepupal, pupal and adult deformity also occurred as a result of the chemical. The maximum deformity was recorded at lower concentrations. The larval and pupal life span was increased by 29.52 and 38.46%, respectively, where as adult life was decreased by 54.54%. The survival period of adults was decreased as concentrations were raised to higher level.

Somasundaram and Chockalingam (1988) studied the impact of diflubenzuron on the feeding physiology of *Papilio demoleus*. Topical application and oral administration of diflubenzuron on the feeding budget in the 5th-instar larva was done. The LD50 and LC50 of diflubenzuron were 13.50 and 9.00 /ug/larva, respectively, after a period of 48h. Of the 2 modes of application, topical application produced 50% mortality at a comparatively low dose of 900 /ug/larva. The growth efficiency was reduced by 44.54% in oral administration and 38.19% in topical application at the highest sublethal doses of 2.7 and 1.8 /ug/larva, respectively, compared with that of control larvae. In addition, the compound produced morphological abnormalities in the adult.

Khan and Srivastava (1989) reported the biological effect of diamino-furyl-s-triazine, used larval residual and adult feeding treatment, on the larval development and mortality of *Euproctis icillia* Stoll. The compound was highly toxic to the larval stage, effective growth inhibitor and successful sterilant in adult stage of *E. icilia* Stoll. It produced maximum 88.88% and minimum 33.33% net mortality at 12.0 and 0.0012 /ug/cm^2 level of residual deposit, respectively. Besides, different types of deformities were exhibited at lower concentrations; high concentration produced complete lethal action. The chemical significantly increased larval and pupal survival period and reduced the adult life span. The maximum larval and pupal survival period was increased upto 54.54 and 69.23%, respectively, but the adult life span was decreased maximum by 13.75%.

Srivastava and **Srivastava (1990)** reported that the reduction in food consumption, weight loss during exposure period and reduction in growth rate occurs, when third and fifth instar larvae of *Pericallia ricini* (Fabr.) were fed on castor (*Ricinus communis)* leaves dipped in different concentrations of diamino-furyl-s-triazine. Maximum reduction in total food consumption noted was 63.40% at 0.01% level, in third instar larval feeding treatment. During the exposure period, larvae lost their weight (maximum by 36.46% in third instar larvae). Maximum reduction in larval growth was also recorded in third instar larvae, which was 63.08% at 0.01% level. With the increase of concentration, the reduction in food consumption and growth rate was increased considerably. The chemical was more active on third instar than fifth instar larvae.

Gupta and **Verma (1991)** studied the effect of three 1-(2,6-disubstituted benzoyl)-3-phenyl urea compounds, namely, penfluron, diflubenzuron and AI3-63220 on pupae of *Corcyra cephalonica.* The compound caused complete mortality when pupae were dipped in 100ppm acetone solution. The mortality increased with increase in concentration from 10 to 100 ppm. The fecundity and egg viability of adults emerged from treated pupae was reduced significantly with penfluron resulting in maximum net control of reproduction (70.1%), followed by diflubenzuron (24.8%) and AI3-63220 (23.9%), at 40 ppm.

Masih (1992) studied the biological interaction of insect growth regulators with lepidopterous pests namely, *Eubroctis icilia* Stoll and *Euproctis fraterna*

MO. of the family Lymantriidae. The pests were administered with the insect growth regulators (penfluron and diaminofuryl-S-triazine) by feeding and residual technique. He observed that the insect growth regulators proved as high toxicant causing remarkable mortality in immature stages. Various degree of morphological abnormalities were also noticed. Food consumption was very much reduced. Chemicals affected the development of normal adults as growth of the treated larvae was reduced extremely in comparison to control.

Sharma (1993) observed the effects of certain insect growth regulators on the growth and development of *Utetheisa pulchella* Linn. She found that the diflubenzuron, penfluron and diamino-furyl-S-triazine were high powered toxicant in adult feeding and residue film treatment. All chemicals affect the growth and development of *U. pulchella* significantly.

Arora and **Co-researchers (1993)** tested diflubenzuron for its toxicity to egg, grubs and cocoons of *Chrysoperla carnea*. Applications of DFB to 0-1, 1-2, and 2-3 old eggs of *C. carnea* resulted in 38.4, 21.6 and 24.8% mortality. Delayed mortality in larval stage was also observed and was highest (49.6%) in the treatment of older (2-3 days) eggs. Feeding of larvae on DFB (0.1%) treated eggs of *Corcyra ephalonica* resulted in complete mortality by the 5th day. In contrast to this, cocoons sprayed with 0.1%. DFB yielded more than 70% normal adults.

Singh *et. al.* (1993) tested nine insecticides, cypermethrin, carbaryl, deltamethrin, diflubenzuron, endosulfan, fenvalerate, fluvalinate, monocrotophos and quinalphos against 2-day old eggs of *Helicoverpa armigera* and all except endosulfan were also tested against 1 day old eggs of *Earias uittella*. Diflubenzuron had no significant effect on egg hatch in *H. armigera*, while all the other treatments significantly reduced egg hatch.

Gupta and other workers (1994) showed that the *Corcyra cephalonica* was quite capable of developing resistance to the diflubenzuron. So this compound yet not widely used for the control of pests.

Ogisso and Asayama (1994) reported the effect of flnoxiculve on 4th and 5th instar silkworm larvae which resulted in a large proportion of larvae failing to spin cocoons. When fed on artificial diet containing moulting hormone, the larvae began to spin cocoon of normal size.

Mridula Gupta and Co-workers (1994) studied the effects of diflubenzuron on eggs of *Diacrisia obliqua* in the laboratory. Eggs aged 0-24, 48-72 and 96-120 h were dipped for 2 min. in 5, 25, 50, 100, 250, 500 and 100 - ppm diflubenzuron. The LC50 was 29.5, 90.0 and 680 ppm for 0-24, 48-72, 96-120 h old eggs, respectively. Abnormal adults emerged from 0-24 h old eggs treated with 100 p.p.m. diflubenzuron.

Wang *e.t, al.* **(1995)** studied the effects of diflubenzuron on cuticle proteins and chitin in last instar larvae of *Mythimna separata*. They observed that diflubenzuron reduced the contents of various cuticle proteins. Diflubenzuron inhibited the synthesis of cuticular chitin and protein and also changed the structure of the complex of chitin-protein. At the initial moult stage in the 6th instar, the contents of DNA and RNA were increased but later RNA decreased rapidly and so did the ratio of RNA:DNA.

Kadam *et. al.* **(1995a)** determined the effect of diflubenzuron on newly oviposited eggs, eggs prior to hatching, larval and pupal stages of *Plutella xylostella*. The percentage unhatched eggs ranged from 22.40 to 100.0 and 17.5 to 77.5 at various treatments for newly oviposited eggs and eggs prior to hatching. The percentage larval mortality ranged from 41.67 to 100.0, 6.66 to 100.0, 0.0 to 100 and 0.0 to 66.67 for the first to fourth instars. The percentage adult emergence from treated eggs was 13.33 to 100.0 compared to 100.0 for the untreated control. Affected larvae failed to moult turned black and displayed morphological deformities. **Kadam** *et. al.* **(1995b)** also concluded that diflubenzuron adversely affected larval growth and weight when applied against castor semilooper.

Gupta *et. al.* **(1995)** studied the effect of diflubenzuron on the larvae of *Corcyra cephalonica* and reported that the early larval stages were found to be more susceptible to the compound than the advanced stages. At low concentration

diflubenzuron was ineffective in causing any mortality in 16 and 30 day old larvae, while development was completely arrested in 2-day old larvae, however, some pupal mortality was observed at these concentrations. The mortality rate was much higher when 16 and 30 days old larvae were fed on higher concentration, however, no adults emerged. Only, males were found malformed.

Staneva and Gencheva (1996) applied Alsystin 25 WP and Dimlin 25 WP at different doses against *Grapholitha molesta* as a part of an Integrated Pest Management Programme for peaches in fields. Treatments were applied in intervals of 35-38 days. As a result, population of the pest in different season found controlled.

Ishaaya et. al. (1996) found Novaluron as good stomach and contact poison. It was found highly active against lepidopterous larvae (by ingestion) and against nymphs of *Bemisia tabaci* (by contact). Novaluron was much more active against eggs and larvae of *B. tabaci* than chlorfluazuron. At a concentration of 1 mg a.i./litre, novaluron reduced adult emergence by w 90%, when first instar larvae were exposed to treated cotton seedlings. Novaluron was also active in suppressing developing stages of the leaf miner, *Liriomyza huidobrensis*, suppersion of about 80% adult formation was obtained at a conc. of 0.8 mg a.i./litre and similar inhibition of pupation and mine formation at a conc. of 20 mg. a.i./litre so it should considerable potential for controlling lepidopteran pests in field crops, vegetables and ornamental plants.

According to **Weiland** *et. al.* **(1996),** Dimlin was found to be effective in controlling *Spodoptera exigua*. **Rigo** and **Goio (1996)** reported some growth regulators like esaflumuron, triflumuron, teflubenzuron and lufenuron and found effective against the tortricid *Cydia molesta* and *Annarsia lineatella*. The best time to apply the growth regulators was established based on the number of adults captured in phenomenon types. Triflumuron was very effective in controlling the pests.

According to **Smagghe** *et. al.* **(1996)** Tebufenozide, representing a new group of insect growth regulators with a new and selective mode of action. Administration via larval diet was an effective way to kill last instar larvae of *Plodia interpunctella* and *Ephestia kuchniella*. The LC50 was calculated to be about 0.3-0.6 mg a.i./kg. diet. Treated larvae underwent head capsule apolysis leading the double head capsule formation, lost weight and died without splitting off the cuticle. The salient effects of moult induction and growth inhibition agree with the specific activity of tebufenozide and confirm its ecdysteroid mimicking action.

Franca and **Branco (1996)** reported that insect growth regulators affect moulting in lepidopteran, dipteran and hemipteran insects. These insecticides are specially recommended for integrated pest management programmes because they are efficient insect control agents, selective to natural enemies and they confer long term protection to the plants.

Arora *et. al.* (1996) evaluated diflubenzuron in the laboratory against different larval instar of *Spodoptera litura* using cotton cv.F 414 as a host plant. There was no mortality among the larvae after feeding for 12 h on DFB-treated cotton even at the highest concentration of 0.2%. Larvae feeding for 24, 48 or 72 h on DFB – treated cotton resulted in partial to complete mortality. The increase in feeding period on the treated cotton resulted in a large increase in the toxicity of DFB, a 72 h feeding period on cotton treated with 0.005% DFB resulted in a cumulative mean mortality of 47.33%. In the first to third instar larvae, maximum mortality occurred at the time of next moult. There was delayed mortality at the time of the larval-pupal moult. At the lower concentrations, only delayed mortality was recorded.

Krishnaiah *et. al.* (1996) reported in Andhra Pradesh, India that at a concentration of 0.01%, buprofezin exhibited a high degree of persistent toxicity to nymphs of the rice brown plant hopper and the white backed plant hopper but only moderate toxicity to the green leaf hopper. The synthetic pyrethroids, cypermethrin and deltamethrin showed moderate toxicity to BPH and WBPH but were highly effective against GLH. combinations of Cypermethrin + buprofezin and deltamethrin + buprofezin were highly effective against above mentioned pests. Buprofezin was safe to nymphs and adults of the predater *Cyrtorthinus lividipennis.*

Bhattacharaya *et. al.* **(1997)** evaluated the toxicity of diflubenzuron against larvae of *Eublemma amabilis*. They used five concentrations ranging from 0.0125 to 0.2% by two methods, oral and topical. Diflubenzuron applied using both method exhibited larvicidal action and caused ecdysial failure which adversely, affected survival. The percentage mortality varied from 56.67 to 93.9 and 46.67 to 90.00 by oral and topical application respectively. Also, 0.05% diflubenzuron sprayed on colonies of *K. lacca* suppressed population of *E. amabilis* without affecting *K. lacca*.

Guo-SJ *et. al.* **(1997)** conducted laboratory and field trials in China to evaluate the efficacy of organophosphorus synthetic pyrethroid, carbamate, insect growth regulators, antibiotic and botanical insecticides to control *Spodoptera litura*. Chlorpyrifos beta-cyfluthrin, methomyl and chlorfluazuron were the most effective.

Kumari and **Mohamed** **(1997)** observed that the carbohydrate concentration in ovaries from adults of the noctuid *Spodoptera mauritia* treated as larvae with diflubenzuron was reduced compared with the carbohydrate concentration in ovaries of adults developing from untreated larvae.

Hull and **Biddinger** **(1997)** divided the insect growth regulators into four groups based on their mode of action, namely chitin synthesis inhibitors (CHI), Juvenile hormone analogues (JHA), anti juvenile hormones and ecdysone agonists. Field studies were carried out during 1994-96 in two apple orchards in

Pennsylvania, U.S.A., on the effects of the ecdysone agonist confirm on lepidopterous pests and natural enemies unharmed and controlling pests.

Smagghe *et. al.* **(1997)** reported that when diflubenzuron was topically applied to larvae of *Spodoptera littoralis* and *Spodoptera exigua*, the estimated LD50 values were similar, reaching 0.47 and 0.44 gva/larvae respectively. In this study, the importance of the rate of uptake and excretion, and of enzymatic metabolism in building up an insecticidal toxicity after topical application on the insect cuticle in both species was evaluated. In general, penetration of DFB in *S.littoralis* was about 2-fold higher than in *S. exigua*, whereas metabolic breakdown was of minor importance in *S. littoralis* as compound with *S. exigua*.

Blumel and **Hausdorf (1997)** carried out studies on 97 trees in 1995 in Vienna, Austria, to test the effectiveness of three synthetic chitin synthesis inhibitors (Dimlin, Alsystin and Insegar) for the control of *Cameraria ohridella*. Dimlin and Alsystin resulted in 98-100% mortality of larvae, depending on the number of applications.

Cadogan *et. al.* **(1997)** conducted a field trial in Canada to determine the efficacy of tebufenozide against *Choristoneura fumiferana* and observed that the spraying of this insecticide effect the development significantly. The larval and pupal weights of treated insects differed significantly. A number of spray applications were found effective in determining a successful application strategy.

Moraschini (1998) reported a new insect growth regulator, showed wide spectrum of activity against many lepidoptera and coleoptera. Its good efficacy, associated with its lack of toxicity against the most common beneficial arthropods. It was found useful in integrated control programmes in the field and greenhouse.

Tembhare (1998) reported that topical application of the Dimlin to 5th instar larvae of *Othreis materna* resulted in an accumulation of neurosecretory cells and cessation of secretary cells in the corprora allata. The prothoracic glands did not resume growth in Dimlin treated larvae. The results suggested that Dimlin inhibits moulting due to neuro endocrine failure.

Saxena and Khattri (2000) reported that the fourth generation insecticide, penfluron applied by pupal dip method, adult feeding method and residue film method to investigate the effects on growth development against *Pericallia ricini* F, (Lepidoptera : Arctiidae). Different concentrations (0.0001, 0.001, 0.01, 0.50, and 1.00 per cent) of penfluron were applied in this investigation. One per cent penfluron affected the growth significantly. Larva gained weight 1.67 mg on fifth day, 6.81 mg on tenth day and 20.92 mg on fifteen day i.e., for less in comparison of control experiment (4.30, 22.64 and 110.93 mg on 5th, 10th, and 15th day). One percent penfluron also effected larval period, pupal period and emergence of this insect significantly. At regard to method of application, the pupal dip method proved the most effective.

In the same year **Saxena and Khattri** also studied effects of diflubenzuron on emergence, longevity and reproduction of *Pericallia ricini* F. (Lepidoptera : Arctiidae) and reported that the diflubenzuron when applied by pupal dip method effect the emergence and longevity both significantly. Emergence and longevity both were found be inversely proportional to the strength of diflubenzuron. One percent diflubenzuron was found to be the most effective. It reduced emergence to about one fifteenth of the natural emergence. It also reduced the longevity by six days in male and female moths. The oviposition and hatching were influence significantly by the diflubenzuron when applied by pupal dip method. One percent diflubenzuron was most successful in reducing the number of eggs laid and hatching of eggs also. It caused about one fourth reduction in oviposition volume and reduced the hatching to 38.4 percent.

Saxena, Kumar and **Khattri (2001)** studied the effects of diamino-furyl-s-triazine and Benzoyl Phenyl Urea on the growth and reproduction and reported that both fourth generations insecticides effected the same significantly. They found both insect growth regulators were effective in controlling the population of *Pericallia ricini*.

Chapter - III

Materials and Methods

MATERIALS AND METHODS

In the present chapter details of materials used and the techniques employed for various experiments of the proposed investigation are dealt, herewith under the following heads.

3.1 Test Insect:

Black Hairy Caterpillar, *Pericallia ricini* Fabricius.

Systematic Position:

- Phylum-Arthropoda

- Class-Insecta

- Order-Lepidoptera

- Family-Arctiidae

- Genus-*Pericallia*

- Species-*ricini*

Sources:

Male and Female, *Pericallia ricini* Fab. were collected in third week of July, 1997 on various agricultural crops and wild hosts, but it certainly manifests the marked preference for castor in field. Their large population and swarms marching and assuming the status of army worms may be seen during rainy season (July-October).

3.2 Laboratory Stock Of The Insect:

The insect was reared and maintained in the laboratory in order to ensure regular supply of the insect and its immature stages during whole tenure of the present investigation as described below.

To begin with, the stock was established with the help of field collected moths. These moths were maintained on 10 per cent sugar solution in glass chimneys with castor leaves. Eggs obtained from them were kept as such for hatching. Larvae hatched from egg were transferred on tender castor leaves in petridishes (15 cm dia) and reared on them till pupation. The food supply to larvae was renewed twice a day in view of evaporation of water, which proceeds fast when leaves are detached from plants. The castor leaves were treated with $KMnO_4$ solution for five minutes followed by washing in running water. These leaves were dried under shade and provided to the experimental larvae. The larval period lasted for about 24-30 days. All possible precautions were taken to save

larvae from bacterial and fungal infections. The first and second instars were reared in petridishes but from third instar to pupation they were reared in pneumatic troughs (25cm dia.) in small groups. When larvae acquired full growth and stopped feeding, they were transferred in separate pneumatic troughs having 6 inches thick moist soil layer on their bottoms. The larvae pupated either on the surface or on the sides of the trough. They mostly pupated on the soil surface. Pupae, thus obtained were kept as such for eclosion. Moths emerged from pupae were obtained from their eggs were reared in pneumatic troughs as described above. In this way the progeny of moths of succeeding generations were reared generation after generation continuously till the tenure of the investigation.

The laboratory reared insects and larvae were maintained throughout the year in the Department of Zoology, D.V. College, Orai by the technique of Helms and Raun (1971) with slight modifications as when found necessary.

3.3 Chemicals Used:

The following fourth generation insecticides whose efficacy as insecticides has already been proved in different crop pests employed against *Pericallia ricini* in this investigation.

- ◆ Diflubenzuron

- ◆ Diamino-furyl-S-triazine

◆ Penfluron

◆ Benzoyl Phenyl Urea

3.4 Concentrations of Chemicals Used:

The different concentrations of chemicals mentioned earlier, were applied against *P. ricini*. The concentrations considered in this work included 0.0001, 0.001, 0.01, 0.10, 0.50 and 1.00 per cent. These concentrations were obtained by dissolving the desired quantity of chemical in acetone or methanol.

3.5 Methods Of Application Of Insect Growth Regulators:

The insect was treated with different concentrations of insect growth regulators used in this work by following three methods.

3.5A Pupal dip Method:

In this method pupae were dipped in a particular concentration for 2 minutes. After dipping for the fixed duration the pupae were taken out from that concentration of the insect growth regulator. The solvent and the chemical adhering to the surface of the pupae were soaked in the blotting paper and such

treated pupae were maintained for further studies. This method from henceforth will be referred as PDM in the text.

3.5B Residue Film Method:

In this method of treatment 1 to 2 hr old adults were exposed to a thin film of residue of a concentration of a particular insect growth regulator. For obtaining the thin film of the chemical as residue, about 10 ml of a concentration of a chemical was poured in a petridish (10 cm dia.) and the petridish was tilted in different ways to spread the chemical on the whole floor area of the petridish and its raised periphery. Thereafter, the petridish was kept in the air for the evaporation of the solvent. This led to the formation of a thin film of a concentration of an insect growth regulator in the petridish as residue. Adults were left in petridishes having thin film of the insect growth regulator for 24 hours. The petridishes were covered by thin muslin cloth to prevent the escape of the adults. Such treated adults were employed in the different experiments as described later on. This method of treatment will be designated as RFM in the text from here onwards.

3.5C Adult Feeding Method:

In this method of treatment a concentration of a particular insect growth regulator was mixed in 20 per cent sugar solution which was supplied to adults for

feeding. From here onwards this method of treatment will be referred as AFM in the text.

3.6 Designes OF Studies:

Studies presented in this thesis were conducted experimentally under laboratory conditions of temperature and relative humidity. These studies were carried on under five main headings:

- The effect of insect growth regulators on growth,

- Effect of Insect Growth Regulators on food consumption,

- The effects of insect growth regulator on development,

- The effects of insect growth regulators on fecundity and fertility

- Sex specific sterility effect of insect growth regulators on reproduction.

These aspects were studied as under :

3.6A Effects Of Insect Growth Regulators On Growth

This was studied in terms of accumulation of bio mass in larva at regular intervals and acquisition of biomass in both pupa and adult and was evaluated as under:

3.6A.I The Influence Of Insect Growth Regulators On Biomass Accumulation In Larva:

This was studied under three different conditions of treatment. In the first condition, a strength of insect growth regulator was applied to the insect at pupal stage by dip method. In the second and third conditions the adults were treated with a strength of insect growth regulator by A.M.F. and R.M.F. as described at 3.5. For convenience, these conditions of treatment have been referred here in as a, b and c treatments respectively. The influence of an insect growth regulator on biomass-accumulation in larva under these treatments was studied as follows:

3.6A.Ia. The influence on biomass accumulation in larva under treatment A (PDM):

It was determined by six experiments; one experiments for one strength of insect growth regulator. Each of the six experiment consisted of three replicates and was designed as under:

The larvae of the moths treated with a particular strength of insect growth regulator at pupal stage were reared on soft and tender leaves of castor in replicate till 16th day of their development. The weight of these larvae were noted on 5th, 10th and 15th day of development. The above mentioned record was obtained with reference to each strength of all the tested insect growth regulators. The experiments for each insecticide were accompanied by control.

3.6A. Ib The influence on biomass accumulation in larva under treatment B (AFM):

This was studied by employing larvae of adults treated with a strength of an insect growth regulator by AFM. The influence of an insect growth regulator on the larval growth under this treatment was studied by six experiments, one for each strength, each consisting of 3 replicates. Twenty larvae (1/2-1 hr old) per replicate were reared on tender leaves of castor till the 16th day of their development. The weight of these larvae was recorded on the 5th, 10th and 15th day of their larval duration. These records were obtained with reference to each strength of each insect growth regulator as described above. The experiment designed to determine the influence of insect growth regulator were accompanied by a control.

3.6A Ic. The Influence on Biomass accumulation in Larva under treatment C (RFM):

The larvae obtained from the adult treated with different strengths of the tested insect growth regulators by the RFM were employed for evaluation of their growth was determined with reference to indentical six strengths of each insect growth regulators exactly on the above mentioned pattern and the related records were obtained with reference to them. The experiments for insect growth regulators were accompanied by a control.

3.6.A.II The Effect Of Insect Growth Regulators On Weight Acquisition :

This aspect was studied by applying the insect growth regulator on pupae and adults. The pupae were treated by PDM and adults were treated by AFM and RFM and the studies were made as under:

3.6.AII.a. The effect of insect growth regulators under pupal dip method :

Sixty larvae of adults obtained from pupae treated stock with a strength of insect growth regulator were selected at random and divided into three groups of twenty larvae, each group forming a replicate. The larvae of replicate were reared on soft and tender leaves of castor till their pupation. The pupae thus obtained, when become 6 hr old weighed and their weight was recorded. These pupae were maintained further for the observation of emergence, when moths emerged and discharged meconium i..e. when they were 1 hr old, their weight was recorded. The above study was performed with reference to each strength of all the test insect growth regulators and records referred to as above were obtained.

3.6.A.II.b The effect of insect growth regulators under adult feeding method:

Twenty pairs of adults selected at random from laboratory stock and were treated with a strength of insect growth regulators by AFM. These treated pairs were maintained for oviposition in glass chimneys, one glass chimney housed one pair of adult. When oviposition occurred, eggs obtained were kept on moist filter paper for their hatching. Sixty larvae of such eggs were selected at random and

divided into three groups of twenty larvae, each group constituted a replicate. The larvae of the replicate were reared on tender leaves of host plant until they pupated. The pupae thus obtained when acquired 6 hr age, were weighed and their weight was recorded. These pupae were kept for emergence of adults. On emergence and after having the discharge the meconium the adults were weighted after one hour and their weight was recorded. The aforesaid study was conducted with reference to each strength of every mentioned insecticide and data were obtained in response to treatment with each strength of all the tested insect growth regulators.

3.6 A II c. The effect of insect growth regulators under residue film method :

Twenty pairs of adults selected at random from the rearing stock and were treated with a strength of insect growth regulator for 24 hr in pertidishes and thereafter they were maintained in glass chimenys for oviposition. The eggs deposited were kept for hatching and the sixty larvae of such eggs were selected indiscriminately. These larvae divided into three groups of twenty larvae, each group form a replicate. The larvae of each replicate were reared to obtain their pupae and adults. The pupae when ½ hr old were weighed and their weight was recorded. Besides, adults were also weighed, about one hr old, after discharge of meconium and subsequently their weight was noted in response to treatment with each strength of all the tested insect growth regulators.

3.6 B Effect Of Insect Growth Regulator On Food Consumption:

The food intake was adversely affected by the insect growth regulators, due to the displacement of the mandibles and laburm or due to blockage of the gut. Because of these morphological and physiological deformities, the insect were unable to feed. Therefore, observations were carefully done in order to see the amount of food taken in by the experimental insect. For this known amount of food (by weighing) was supplied to the larvae of insect on test and never allowed to feed for the next 24 hour. After the limited time of feeding was over, the un-consumed food was weighed. This was carried out daily until pupation had taken place. The ratio of food supplied and food consumed gave the percentage of food consumption. The loss of weight in the supplied food (leaves) by oviposition during experimental period was also adjusted with the control, in which the same amount of food that was given to the experimental insect, were kept in the glass chimney without any insect and loss in weight by evaporation was noted everyday.

The faecal matter excreted by the experimental insect and that of the control was weighed daily to see the amount of food digested.

The ratio of food consumed and faecal matter gave the digestive percentage or food digested.

3.6 C. Effect Of Insect Growth Regulator On Development:

The effect of different strength of all the considered insect growth regulator on development was studied in response to their application to the insect by PDM, AFM and RFM separately as described below:

3.6 C.I. Effect Of Insect Growth Regulators On Development Under Pupal Dip Method:

One to two hr old larvae of adult obtained from the pupae dipped in a strength of insect growth regulator were considered for this aspect studied experimentally. One experiment was designed for each strength of insect growth regulator. This experiment consisted of three replicates. Twenty such larvae per replicate were reared on tender leaves of host plants until they pupated. On pupation of these larvae the number of larvae pupated and their larval period were recorded. The pupae of these larvae were kept date wise for emergence of adults and on emergence the pupal period and the number of adults emerged were noted. Besides these the sex ratio was also recorded. The experiment was further extended for recording the life span of male and female. For this purpose males and females were maintained individually date wise in glass chimneys on daily supply of 20 per cent sugar solution till their natural death and on their expiry, their longevity was recorded.

The above mentioned experiment was designed separately for each strength of all the tested insect growth regulators and records refer to above were obtained with reference to each strength of these insect growth regulators. Besides, for the purpose of comparison a control was also set for each insect growth regulator and the records identical to above mentioned for the same.

3.6 C.II Effect Of Insect Growth Regulators On Development Under Adult Feeding Method:

For the evaluation of this, immediately hatched larvae obtained from females fed on a strength of an insect growth regulator, were employed experimentally. This was tested by one experiment designed separately for each strength of insect growth regulator. Twenty such larvae per replicate were reared on tender leaves of host plants under their pupation when pupated their developmental duration and survival were recorded. The pupae thus obtained were kept to obtain adults from them. On emergence of adults, the number of adults emergence and their pupal period were noted. Besides these, the sex ratio of adults was also noted. The experiment was further extended to record life duration of males and females. In order to record longevity of males and females, they were maintained individually as described in the experiment mentioned at 3.6B1 when they expired their longevity was recorded.

3.6 C.III. Effect Of Insect Growth Regulators On Development Under Residue Film Method:

This was studied experimentally with immediately hatched larvae of adults which were already forced to contact a thin residue film of a strength of an insect growth regulator. It was determined in one experiment which consisted of three replicates. Twenty such larvae were reared on leaves of the host plants till their pupation and when they pupated the number of pupated larvae and their larval period were recorded. The pupae thus obtained were kept day wise and when moths emerged from them their number and pupal period were noted. Along with these the ratio between males and females was observed. The above experiment was designed separately for each strength of all the insect growth regulators and record similar to those mentioned above were maintained. Control experiment was set for making comparison in respect of results of different strengths of an insect growth regulator.

Besides the above records under different methods of application of insect growth regulator the record pertaining to net mortality was obtained as suggested by Abbot (1925) as follows:

$$\%\text{Net mortality} = \frac{\%\text{Mortality in test} - \%\text{Mortality in normal}}{100 - \%\text{Mortality in normal}} \times 100$$

3.6 D Effect Of Insect Growth Regulators On Reproduction:

The reproduction in *P. ricini* under influence of different insect growth regulators was studied under two headings:

♦ Effect on reproductive period and fecundity.

♦ Effect on fertility and incubation period.

3.6 D.I Effect Of IGR On Reproductive Periods And Fecundity :

The preoviposition, oviposition periods and the number of eggs deposited by a female were studied separately by applying insect growth regulators to pupae and adults as described under.

3.6 D.Ia. Effect of IGR on reproductive periods and fecundity under PDM:

A lot of about 6 hours old pupae were treated with a strength of an insect growth regulator by dipping them in the same for five minutes. Ten males and ten females obtained from such treated pupae were selected indiscriminately. The females were maintained individually with a male in glass chimney on daily supply of twenty per cent sugar solution for oviposition. When these females laid eggs for the first time, their preoviposition period were recorded. The females were maintained till they deposited last egg and after that their oviposition period was recorded. The eggs were laid during this period were counted and their number was recorded. The above study was performed for each strength of all the insect growth regulators and the above mentioned records were obtained for them.

A control experiment was also set for each insect growth regulator. The fecundity along with reproductive period was also recorded for the control.

3.6 D.Ib. Effect of IGR on reproductive periods and fecundity under AFM:

Ten females and ten males were drawn at random from the laboratory stock. The females were maintained in glass chimneys with a male and twenty per cent sugar solution containing a strength of an insect growth regulator for oviposition. Each pair constituted a replicate. When the female of a replicate laid eggs for the first time, the preoviposition period was recorded. The female was maintained as such to lay her eggs and when the last egg was deposited, the oviposition period was noted. Besides, the eggs laid during the oviposition period were counted and their number was recorded. The above study was made separately for each strength of all the tested insect growth regulators and above mentioned records were obtained for them. Besides, a control was also designed for each insect growth regulator.

3.6 D.Ic. Effect of IGR on reproductive period and fecundity under RFM:

Ten females along with ten males were selected at random from the laboratory stock. Both males and females were compelled to contact a thin film of a strength of an insect growth regulator for 24 hrs. Thereafter, the females were maintained in glass chimneys with a male on twenty per cent sugar solution for egg laying when the first egg was laid, the preoviposition period recorded. The

females were maintained as such till the deposition of their last egg, after which the oviposition period was recorded. The total number of eggs laid during the oviposition period was recorded. The above mentioned study was conducted separately for all concentrations of the tested insect growth regulators and the above mentioned records were obtained for them also. The studies for an insect growth regulator were accompanied by one control experiment.

3.6 D,II   Effect of Insect Growth Regulators On Fertility And Incubation Period:

The influence of insect growth regulators on fertility and incubations period was studied with reference to PDM, AFM and RFM as follows:

3.6 D.IIa   Effect of insect growth regulators on fertility and incubation period under PDM:

A lot of pupae was drawn from laboratory stock and then same were treated with a strength of insect growth regulator. After the treatment, the pupae were kept for emergence. The emerging moths were maintained in order to obtain eggs. The eggs of each pair were collected daily and kept date wise on moist filter paper. On hatching of the eggs, the number of eggs hatched and their incubation period were recorded. The above study was undertaken for each strength of all the insect growth regulators and the above mentioned records were obtained. A

control experiment was set for every insect growth regulator and similar records for the control were also maintained.

3.6 D.IIb. Effects of insect growth regulators on fertility and incubation period under AFM:

Ten females and ten males, each ½ hr old were drawn indiscriminately from the laboratory stock. These were organised in ten pairs. Each pair was maintained in glass chimney with 20 per cent sugar solution which contained a strength of insect growth regulator. Each pair represented a replicate. The eggs from each replicate collected daily and maintained as described above. When the eggs hatched, their viability and incubation period were recorded. The above study was under taken with reference to different strengths of all the tested insect growth regulators and records as mentioned above were also obtained. Studies meant to determine the influence of every insect growth regulator on the viability and incubation period of eggs were accompanied by a control for the above mentioned records with reference to the same.

3.6 DII.c Effect of insect growth regulators on fertility and incubation period under RFM:

This aspect was studied in a experiment which was designed separately but identically for each strength of all the tested insect growth regulators. The experiment consisted of ten replicates. For the study, ten females and ten males

were drawn from the laboratory stock. These moths were compelled to contact thin residue film of a strength of insect growth regulator for 24 hrs and thereafter these were maintained as pairs in glass chimneys with twenty per cent sugar solution; each chimney had one pair of moths. Each moths pair made a replicate. Eggs from each replicate were collected daily and kept date wise for hatching. On hatching of the eggs, their viability and incubation period were recorded. The experiment for each insect growth regulator was accompanied by a control.

Besides the above mentioned records, the records pertaining to the reduction in the fecundity, net sterility and control over reproduction were also obtained as detailed below.

The reduction in the fecundity was calculated following the formula of Chamberlain (1962) as detailed below:

$$\% \text{Reduction in fecundity} = \frac{\text{Eggs laid in normal} - \text{Eggs laid in test}}{\text{Eggs laid in normal}} \times 100$$

The sterility was calculated following the formula of Abbot (1925) as described below:

$$\% \text{Net sterility} = \frac{\% \text{Sterility in test} - \% \text{Sterility in normal}}{100 - \% \text{Sterility in normal}}$$

The control over the reproduction was calculated following the formula of Chamberlain (1962) as described below:

$$\%Control\ over\ reproduction = \frac{Eggs\ hatched\ in\ normal - Eggs\ hatched\ in\ test}{Eggs\ hatched\ in\ normal} \times 100$$

3.6 E Sterility Effect Of Insect Growth Regulators On Sexes:

Studies described at serial 3.6C did not project the sex specific influence of the tested insect growth regulators. In order to determine this, the following study was carried by monitoring matings between treated female and untreated male and between untreated female and treated male. This was studied with reference to each strength of all the tested insect growth regulators separately by two experiments, each consisting of two replicates. The females or males employed in the experiments were treated earlier by PDM.

For the first experiment ten females treated at pupal stage with a strength of insect growth regulator were selected at random and ten males were also selected at random from the laboratory stock of course not treated with an insect growth regulator. Males and females were mixed together and divided immediately into ten pairs. Each pair, making replicate, was maintained in a glass chimney. The eggs laid by the female of each replicate were collected and kept date wise for hatching. On the hatching of eggs, the number of eggs hatched was recorded. This experiment was accompanied by a control experiment.

For the second experiment ten males, treated with a strength of an insect growth regulator were selected at random like wise, ten females (of course

untreated ones) were also selected at random from the laboratory stock. Males and females were mixed and divided into ten pairs, each pair made a replicate. A moth pair was maintained in glass chimney with twenty per cent sugar solution for oviposition. The eggs were laid were collected daily and kept date wise for hatching. When eggs hatched, their viability was recorded. Like the first experiment, this experiment, was also accompanied by a control.

3.7 STATISTICAL ANALYSIS:

The data obtained from the studies were subjected to statistical analysis. Various statistical techniques mentioned below have been applied to study the nature and relationship between variables, to known the reliability and precision in the results obtained, to test the significant difference between the observed and corresponding expected values and to predict the estimated values of effectiveness for a given value of concentration.

♦ **Standard Error:**

It is used for estimating the errors which are likely to be there in the average of the values obtained in the different replicates of experimental treatments. The standard error has been calculated with the help of the following formula.

$$SE = \frac{S.D}{\sqrt{n}}$$

where

n = Number of generations.

S.D. = Standard Deviation.

Standard deviation was calculated by the following expression -

$$S.D. = \sqrt{\sum \frac{(x - x)^2}{n}}$$

Where,

x = observation of variate values

x = Arithmetic mean of the observation

n = Number of observations.

♦ **Significance Test:**

The significance test was done to reveal, whether the difference in the results obtained at the different levels were due to errors of sampling or there existed real differences between the treatments.

+ **<u>Chi Square Test (x^2 test) :</u>**

For testing the independence or association between the effectiveness and concentrations, x^2 test was also used. The heterogeneity of the data was tested maximum at 5% probability level.

Chapter - IV

Observations

OBSERVATIONS

The administration of diflubenzuron, penfluron, diamino-furyl-s-triazine and benzoyal phenyl urea was done by pupal dip method, adult feeding method and residue film method to <u>Pericallia ricini</u> Fab. to see the effect on the growth and development. These effects were studied under five main headings-

♦ Effect on growth

♦ Effect on food consumption

♦ Effect on post-embroyonic development.

♦ Effect on reproduction

♦ Sterilizing effects on male and female sexes.

Except the above heads of study, food intake and utilization of food also studied. All results obtained in different experiments are presented in tabulor form in the following pages. Suitable bar diagrams and graphs are also included in this chapter.

TABLE - 1

Effect of different concentrations of Diflubenzuron under different modes of treatment on biomass accumulation in larvae of _Pericallia ricini_ Fab.

(Values are mean ± S.E.)

Mode of treatment	Concentration (%)	Larval biomass (mg) on		
		5th day	10th day	15th day
PDM	.0001	3.80±0.09	15.71 ± 0.26	67.62±0.48
	.001	2.71±0.16	13.82±0.32	58.20±0.48
	.01	2.42±0.13	11.36±0.37	47.17±0.40
	.10	2.74±0.11	10.70±0.30	47.17±0.40
	.50	1.75±0.11	8.82±0.38	29.74±0.58
	1.00	1.67±0.10	6.80±0.26	20.64±0.48
AFM	.0001	3.82±0.11	15.76±0.31	71.06±0.52
	.001	2.94±0.15	13.85±0.38	60.20±0.60
	.01	2.74±0.12	11.85±0.48	49.47±0.45
	.10	2.46±0.10	10.26±0.36	38.46±0.58
	.50	2.00±0.09	8.62±0.41	30.46±0.52
	1.00	1.76±0.11	6.94±0.32	22.57±0.64
RFM	.0001	3.82±0.14	15.77±0.40	72.46±0.46
	.001	2.95±0.16	13.87±0.42	61.34±0.57
	.01	2.76±0.11	11.40±0.40	50.26±0.68
	.10	2.43±0.18	10.36±0.48	39.46±0.54
	.50	2.00±0.09	8.84±0.36	31.93±0.60
	1.00	1.80±0.12	6.84±0.38	23.88±0.76
	Control	4.30±0.10	22.64±0.52	110.93±0.80

TABLE - 2

Effect of different concentrations of penfluron under different modes of treatment on biomass accumulation in larvae of <u>Pericallia</u> <u>ricini</u> Fab.

(Values are mean ± S.E.)

Mode of treatment	Concentration (%)	Larval biomass (mg) on		
		5th day	10th day	15th day
PDM	.0001	3.81±0.11	15.73±0.32	71.14±0.42
	.001	2.81±0.12	13.84±0.28	56.73±0.68
	.01	2.43±0.16	11.54±0.36	49.24±0.62
	.10	2.36±0.14	10.36±0.39	36.88±0.55
	.50	1.92±0.10	8.96±0.32	29.75±0.46
	1.00	1.67±0.08	6.81±0.38	20.92±0.48
AFM	.0001	3.84±0.10	15.76±0.34	72.24±0.38
	.001	2.96±0.14	13.85±0.28	56.84±0.72
	.01	2.76±0.16	11.58±0.44	49.36±0.62
	.10	2.66±0.12	10.32±0.26	38.38±0.56
	.50	1.99±0.08	8.97±0.22	29.90±0.68
	1.00	1.78±0.11	6.83±0.36	21.04±0.22
RFM	.0001	3.83±0.14	15.76±0.24	73.26±0.30
	.001	2.97±0.10	13.89±0.31	58.90±0.52
	.01	2.76±0.12	11.38±0.20	50.66±0.48
	.10	2.64±0.16	10.35±0.16	36.90±0.60
	.50	2.00±0.10	8.98±0.24	30.86±0.43
	1.00	1.85±0.08	6.86±0.32	23.88±0.76
	Control	4.30±0.10	22.64±0.52	110.93±0.80

TABLE - 3

Effect of different concentrations of Diamino furyl-s-triazine under different modes of treatment on biomass accumulation in larvae of Pericallia ricini Fab.

(Value are mean ± S.E.)

Mode of treatment	Concentration (%)	Larval biomass (mg) on		
		5th day	10th day	15th day
PDM	.0001	3.74±0.12	15.76± 0.30	71.46±0.46
	.001	2.70±0.12	13.84±0.24	58.72±0.62
	.01	2.44±0.14	11.35±0.28	48.25±0.68
	.10	2.34±0.09	10.18±0.16	37.17±0.72
	.50	1.98±0.10	8.96±0.32	29.82±0.46
	1.00	1.68±0.12	6.82±0.36	20.92±0.40
AFM	.0001	3.94±0.08	15.82±0.32	72.14±0.26
	.001	2.78±0.12	13.89±0.40	56.96±0.46
	.01	2.76±0.09	11.44±0.38	50.00±0.42
	.10	2.35±0.14	10.08±0.26	37.00±0.60
	.50	1.98±0.10	8.92±0.22	30.00±0.64
	1.00	1.79±0.12	6.88±0.26	22.46±0.48
RFM	.0001	3.93±0.09	15.79±0.28	72.36±0.34
	.001	2.98±0.12	13.88±0.30	57.04±0.68
	.01	2.79±0.08	11.39±0.22	51.40±0.56
	.10	2.42±0.12	10.27±0.18	37.40±0.62
	.50	1.86±0.08	8.90±0.24	30.20±0.48
	1.00	1.74±0.11	6.93±0.32	22.57±0.58
	Control	4.30±0.10	22.64±0.52	110.93±0.80

TABLE - 4

Effect of different concentrations of Benzoyl Phenyl Urea under different modes of treatment on biomass accumulation in larvae of <u>Pericallia ricini</u> Fab.

(Values are mean ± S.E.)

Mode of treatment	Concentration (%)	Larval biomass (mg) on		
		5th day	10th day	15th day
PDM	.0001	4.16±0.08	16.30±0.28	75.23±0.46
	.001	3.14±0.10	14.12±0.22	64.25±0.68
	.01	2.88±0.12	12.56±0.22	54.24±0.76
	.10	2.51±0.14	10.66±0.20	42.87±0.52
	.50	1.99±0.10	9.43±0.14	34.24±0.66
	1.00	1.82±0.12	7.36±0.24	28.35±0.82
AFM	.0001	4.28±0.10	16.18±0.28	76.80±0.42
	.001	3.34±0.12	14.16±0.16	65.92±0.56
	.01	3.10±0.12	12.56±0.26	54.66±0.78
	.10	2.62±0.14	10.46±0.20	45.42±0.60
	.50	2.36±0.08	9.54±0.22	35.24±0.48
	1.00	1.86±0.10	7.90±0.18	29.62±0.72
RFM	.0001	4.38±0.12	16.28±0.16	77.90±0.60
	.001	3.26±0.09	14.16±0.20	67.92±0.42
	.01	3.14±0.12	12.58±0.18	56.24±0.66
	.10	2.64±0.14	10.57±0.14	46.26±0.48
	.50	2.40±0.08	8.98±0.24	38.35±0.40
	1.00	2.20±0.12	6.86±0.32	30.26±0.52
	Control	4.30±0.10	22.64±0.52	110.93±0.80

TABLE - 5

Effect of Diflubenzuron at different concentrations under different modes of treatment on biomass accumulation by pupa and adults in Pericallia ricini Fab.

(Values are mean ± S.E.)

Mode of treatment	Concentration (%)	Weight (mg) of		
		Pupa	Male	Female
PDM	.0001	140±0.46	95.36±0.42	104.46±0.86
	.001	133.50±0.62	91.11±0.48	98.10±0.86
	.01	124.86±0.38	83.46±0.31	90.16±0.97
	.10	110.64±0.62	73.88±0.51	78.02±1.00
	.50	97.21±1.04	44.12±1.92	70.14±1.24
	1.00	69.56±1.47	48.36±2.31	51.39±0.77
AFM	.0001	134.36±0.82	91.42±0.70	101.22±0.88
	.001	126.37±0.66	87.56±0.31	93.48±0.64
	.01	119.76±0.62	79.48±0.64	86.12±0.32
	.10	104.42±0.86	67.10±1.02	72.33±0.86
	.50	91.28±1.20	62.00±0.88	66.10±0.48
	1.00	66.12±1.34	46.02±1.10	48.33±0.47
RFM	.0001	144.42±0.37	96.14±0.76	102.26±0.56
	.001	138.54±0.82	93.88±0.51	105.13±0.72
	.01	126.08±0.65	93.42±0.92	95.78±0.59
	.10	109.12±0.88	88.42±1.02	82.46±1.10
	.50	94.78±1.14	73.16±0.88	76.44±1.00
	1.00	73.16±1.10	54.67±0.92	56.72±1.06
	Control	152.60±0.94	106.47±1.26	112.06±0.92

TABLE - 6

Effect of Penfluron at different concentrations under different modes of treatment on biomass accumulation by pupa and adults Pericallia ricini Fab.

(Value are mean ± S.E.)

Mode of treatment	Concentration (%)	Weight (mg) of		
		Pupa	Male	Female
PDM	.0001	140.80±0.48	94.74±0.62	103.63±0.72
	.001	133.86±0.56	91.12±0.58	97.82±0.83
	.01	125.00±0.91	83.36±0.66	90.10±0.66
	.10	112.70±0.64	72.84±0.82	78.12±0.64
	.50	98.56±1.12	68.72±1.00	69.82±0.88
	1.00	70.23±0.68	48.86±0.46	52.00±0.46
AFM	.0001	135.12±0.73	89.04±0.48	98.80±0.57
	.001	129.44±0.62	86.26±0.62	94.13±0.62
	.01	120.14±0.44	76.14±0.68	84.42±0.70
	.10	108.04±0.66	66.24±0.92	71.82±0.66
	.50	92.36±0.54	64.10±0.66	63.26±0.62
	1.00	66.20±0.54	44.24±0.42	48.10±0.66
RFM	.0001	142.40±0.98	97.80±0.44	107.40±0.44
	.001	137.80±0.84	94.12±0.62	102.10±0.48
	.01	129.12±0.67	86.04±0.66	95.06±0.66
	.10	117.06±0.67	75.54±0.84	84.20±0.52
	.50	103.42±0.82	72.10±0.62	75.20±0.56
	1.00	76.10±0.68	54.02±0.83	55.80±0.61
	Control	152.60±0.94	106.47±1.26	112.06±0.92

TABLE - 7

Effect of Diamino-furyl-s-triazine at different concentrations under different modes of treatment on biomass accumulation by pupa and adults in Pericallia ricini Fab.

(Value are mean ± S.E.)

Mode of treatment	Concentration (%)	Weight (mg) of		
		Pupa	Male	Female
PDM	.0001	140.36±0.82	95.00±0.56	104.10±0.98
	.001	134.76±0.64	90.86±0.32	98.26±0.72
	.01	132.12±0.48	84.12±0.44	91.32±0.54
	.10	111.86±0.68	72.10±0.72	77.48±0.64
	.50	96.40±0.71	67.44±0.66	69.12±0.56
	1.00	71.40±0.42	49.10±0.54	52.16±0.48
AFM	.0001	134.38±0.64	90.82±0.44	97.80±0.66
	.001	127.82±0.60	86.16±0.52	91.74±0.57
	.01	121.10±0.66	8040±0.62	86.40±0.44
	.10	106.46±0.60	67.12±0.58	72.06±0.62
	.50	90.80±0.78	61.44±0.66	64.26±0.47
	1.00	64.56±0.62	44.10±0.42	47.20±0.62
RFM	.0001	143.64±0.58	97.80±0.76	107.36±0.80
	.001	139.76±0.84	93.64±0.44	103.22±0.56
	.01	135.20±0.66	88.26±0.62	98.08±0.64
	.10	115.46±0.73	76.10±0.66	81.70±0.74
	.50	102.84±0.92	71.96±0.48	74.80±0.86
	1.00	78.10±0.61	55.40±0.60	58.16±0.93
	Control	152.60±0.94	106.47±1.26	112.06±0.92

TABLE – 8

Effect of Benzoyl Phenyl Urea at different concentrations under different modes of treatment on biomass accumulation by pupa and adults in Pericallia ricini Fab.

(Values are mean ± S.E.)

Mode of treatment	Concentration (%)	Weight (mg) of		
		Pupa	Male	Female
PDM	.0001	148.62±1.12	101.86±0.84	108.82±1.04
	.001	142.64±0.96	92.42±0.96	100.10±0.96
	.01	136.64±0.88	85.66±0.78	93.44±0.88
	.10	129.46±0.66	76.92±0.84	82.00±0.69
	.50	121.25±0.82	70.64±0.62	73.66±0.64
	1.00	101.45±0.92	56.36±0.70	62.02±0.60
AFM	.0001	142.84±0.90	96.44±0.68	101.84±0.80
	.001	136±0.90	85.10±0.84	95.10±0.60
	.01	129.66±0.88	78.59±0.80	86.36±0.66
	.10	122.20±0.84	69.22±0.78	75.22±0.74
	.50	115.76±0.96	64.46±0.64	68.08±0.70
	1.00	95.22±0.89	48.86±0.48	57.71±0.69
RFM	.0001	153.82±0.99	105.22±0.82	113.62±0.84
	.001	147.14±0.94	98.08±0.69	104.74±0.90
	.01	140.17±0.86	89.14±0.72	98.12±0.94
	.10	134.12±0.82	82.06±0.80	87.64±0.92
	.50	126.64±0.78	75.86±0.84	78.12±0.88
	1.00	107.60±0.94	62.13±0.64	67.85±0.64
	Control	152.60±0.94	106.47±1.26	112.06±0.92

TABLE – 9

Effect of Diflubenzuron on food consumption and faecal matter of <u>Pericallia</u> <u>ricini</u> larvae in larval feeding treatment.

Conc	Table Larval pd	Total amount of food consumed/faecal matter per larvae	Reduction in food consumption	Food digested	
	Days	(g)	(g)	%	%
.0001	11.5	(2.951) 2.924 (0.933)	0.356	20.95	67.75
.001	13.5	2.674 (.856)	0.698	27.36	66.42
.01	13.6	2.396 (.824)	0.884	36.75	65.72
.10	14.0	2.335 (.823)	1.203	38.62	63.82
.50	15.0	3.313 (1.276)	1.203	36.63	31.30
1.00	17.0	1.448 (1.435)	2.377 (1.682)	43.40	29.41
Control	11.00	3.275 (0.951)	---	---	70.93

TABLE – 10

Effect of Penfluron on food consumption and faecal matter of Pericallia ricini larvae in larval feeding treatment.

Conc	Larval pd	Total amount of food consumed/faecal matter per larvae	Reduction in food consumption	Food digested	
	Days	(g)	(g)	%	%
.0001	15.0	3.671 (2.343)	0.950	20.55	36.17
.001	16.0	3.363 (2.336)	1.258`	27.22	30.47
.01	16.5	3.226 (2.314)	1.395	30.18	28.27
.10	17.0	2.750 (1.961)	1.871	40.48	28.69
.50	17.0	2.377 (1.682)	2.139	47.36	29.23
1.00	18.5	2.716 (1.909)	1.905	41.22	29.71
Control	11.00	3.275 (0.951)	---	---	70.93

TABLE – 11

Effect of Diamino-furyl-s-triazine on food consumption and faecal matter of Pericallia ricini larvae in larval feeding treatment.

Conc	Larval pd	Total amount of food consumed/faecal matter per larvae	Reduction in food consumption	Food digested	
	Days	(g)	(g)	%	%
.0001	15.0	3.612 (2.334)	0.951	20.56	36.26
.001	16.3	3.373 (2.347)	1.256	27.24	31.06
.01	16.5	3.227 (2.322)	1.416	29.98	28.96
.10	17.4	2.760 (1.974)	1.964	41.32	29.13
.50	17.8	2.468 (1.664)	1.784	42.46	29.78
1.00	18.5	2.716 (1.918)	1.874	41.44	30.42
Control	11.00	3.275 (0.951)	---	---	70.93

TABLE – 12

Effect of Benzoyal Phenyl Urea on food consumption and faecal matter of Pericallia ricini larvae in larval feeding treatment.

Conc	Larval pd	Total amount of food consumed/faecal matter per larvae	Reduction in food consumption	Food digested	
	Days	(g)	(g)	%	%
.0001	15.0	3.671 (2.343)	0..950	20.55	36.17
.001	16.0	3.0363 (2.338)	1.258	27.22	30.47
.01	16.5	3.226 (2.314)	1.395	30.18	28.27
.10	17.0	2.750 (1.961)	1.871	40.48	28.69
.50	17.0	2.378 (1.683)	1.681	43.40	29.41
1.00	18.5	2.714 (1.908)	1.903	41.22	29.69
Control	11.00	3.275 (0.951)	---	---	70.93

TABLE -13

Effects of Diflubenzuron on post-embryonic development in _Pericallia ricini_ at different concentrations under different modes of treatment.

(Values are mean ± S.E.)

Mode of treatment	Concentration %	Pupation (%)	Larval pd. (days)	Emergence (%)	Pupal pd. (days)	Longevity (days)	
						Male	Female
PDM	.0001	66.66	18.25±0.84	60.00	12.25±0.36	9.48±0.12	13.48±0.16
	.001	56.56	18.93±0.46	32.35	13.93±0.42	9.30±0.12	13.06±0.18
	.01	45.00	19.28±0.85	29.63	15.78±0.28	7.35±0.22	10.36±0.14
	.10	36.36	19.46±0.42	27.27	19.46±0.32	6.70±0.14	8.72±0.14
	.50	31.36	28.40±0.76	21.05	24.60±0.60	5.63±0.11	6.34±0.18
	1.00	30.33	36.73±1.10	16.66	29.72±0.88	3.44±0.16	4.38±0.11
AFM	.0001	68.33	18.36±0.46	60.98	12.20±0.22	9.64±0.21	12.58±0.24
	.001	55.00	19.00±0.32	33.33	13.90±0.18	9.58±0.14	12.26±0.22
	.01	40.00	20.00±0.20	29.17	15.50±0.27	8.36±0.16	11.00±0.26
	.10	31.67	21.20±0.28	26.26	19.40±0.32	7.50±0.22	9.64±0.26
	.50	30.00	28.40±0.32	22.22	24.00±0.41	6.34±0.11	7.42±0.11
	1.00	28.33	34.82±0.68	17.67	29.00±0.56	4.82±0.10	5.62±0.12
RFM	.0001	70.00	18.42±0.24	66.67	12.00±0.18	9.76±0.14	14.00±0.12
	.001	58.33	19.10±0.22	34.29	13.50±0.26	9.00±0.20	12.00±0.14
	.01	48.33	20.24±0.26	34.48	14.66±0.31	8.72±0.26	11.00±0.22
	.10	40.00	21.36±0.18	29.17	18.72±0.36	8.24±0.42	10.42±0.32
	.50	36.36	28.50±0.42	27.27	23.46±0.32	7.36±0.12	8.24±0.16
	1.00	33.333	36.36±0.36	20.00	27.04±0.40	5.00±0.00	6.00±0.10
Control		83.33	15.00±0.34	100.00	11.64±0.21	11.48±0.16	14.30±0.22

TABLE - 14

Effects of Penfluron on post-embryonic development in *Pericallia ricini* at different concentrations under different modes of treatment.

(Values are mean ± S.E.)

Mode of treatment	Concentration %	Pupation (%)	Larval pd. (days)	Emergence (%)	Pupal pd. (days)	Longevity (days)	
						Male	Female
PDM	.0001	70.00	18.25±0.46	61.90	12.20±0.40	9.74±0.14	13.48±0.12
	.001	58.33	18.95±0.42	42.86	13.90±0.36	9.68±0.36	12.18±0.14
	.01	48.33	19.30±0.40	37.93	15.70±0.44	7.83±0.18	10.88±0.16
	.10	40.00	19.50±0.56	33.33	19.40±0.32	7.00±0.26	8.76±0.11
	.50	33.00	24.50±0.38	30.00	23.56±0.56	5.93±0.13	6.56±0.12
	1.00	31.67	36.06±0.82	26.32	28.42±0.84	4.63±0.11	4.44±0.41
AFM	.0001	70.00	18.36±0.16	54.29	12.00±0.20	9.82±0.12	12.52±0.20
	.001	56.56	18.98±0.22	44.11	13.70±0.18	9.00±0.16	12.28±0.26
	.01	46.67	19.20±0.46	46.43	15.00±0.26	8.66±0.22	10.88±0.22
	.10	38.33	20.00±0.52	34.87	19.42±0.32	7.36±0.10	8.26±0.16
	.50	33.33	25.00±0.28	31.66	23.44±0.40	6.42±0.24	6.76±0.28
	1.00	31.66	36.92±0.49	23.32	28.00±0.48	4.78±0.12	5.72±0.10
RFM	.0001	71.67	18.26±0.20	65.12	12.00±0.16	9.28±0.20	13.64±0.28
	.001	60.00	18.96±0.26	44.44	15.40±0.22	9.72±0.10	12.48±0.16
	.01	50.00	19.40±0.22	50.00	18.35±0.46	9.00±0.16	10.90±0.10
	.10	41.67	20.00±0.16	40.00	20.42±0.28	8.712±0.14	9.42±0.16
	.50	36.67	24.00±0.40	33.33	24.32±0.20	7.92±0.26	7.86±0.22
	1.00	33.33	33.32±0.26	30.00	26.24±0.26	5.00±0.16	6.00±0.24
Control		83.33	15.00±0.34	100.00	11.64±0.21	11.48±0.16	14.30±0.22

TABLE - 15

Effects of Diamino furyl-s-triazine on post-embryonic development in Pericallia ricini at different concentrations under different modes of treatment.

(Values are mean ± S.E.)

Mode of treatment	Concentration %	Pupation (%)	Larval pd. (days)	Emergence (%)	Pupal pd. (days)	Longevity (days)	
						Male	Female
PDM	.0001	71.66	18.20±0.46	62.79	12.00±0.32	9.62±0.16	13.76±0.16
	.001	61.66	19.00±0.42	43.33	13.50±0.44	9.57±0.14	12.46±0.12
	.01	48.33	19.36±0.48	41.66	15.66±0.56	7.65±0.26	11.00±0.10
	.10	41.66	22.28±0.56	36.00	19.00±0.42	7.10±0.22	9.00±0.22
	.50	35.00	26.43±0.68	31.66	23.50±0.64	5.88±0.36	8.10±0.18
	1.00	33.00	32.42±0.72	20.00	27.26±0.26	3.64±0.42	6.00±0.22
AFM	.0001	71.66	18.20±0.49	65.60	12.00±0.18	9.72±0.18	12.82±0.26
	.001	60.00	18.98±0.38	44.44	13.60±0.32	9.40±0.20	12.56±0.22
	.01	50.00	19.24±0.42	43.33	15.50±0.40	9.24±0.12	12.00±0.16
	.10	43.43	21.40±0.68	35.00	18.56±0.62	7.64±0.18	10.00±0.12
	.50	36.66	25.24±0.46	31.66	24.00±0.48	6.24±0.22	6.42±0.10
	1.00	31.66	31.50±0.52	21.66	26.56±0.52	4.26±0.20	6.42±0.26
RFM	.0001	79.33	18.34±0.36	65.91	12.00±0.12	9.76±0.10	13.76±0.28
	.001	61.66	18.98±0.32	45.95	13.60±0.26	9.30±0.12	12.40±0.18
	.01	55.00	19.36±0.20	42.42	15.00±0.40	8.66±0.24	10.36±0.26
	.10	40.00	21.50±0.46	37.50	18.36±0.62	7.66±0.16	8.42±0.16
	.50	38.33	25.20±0.26	35.00	23.44±0.46	6.62±0.22	7.36±0.20
	1.00	35.00	30.00±0.42	23.81	25.66±0.64	4.46±0.28	6.94±0.24
Control		83.33	15.00±0.34	100.00	11.64±0.21	11.48±0.16	14.30±0.32

TABLE 16

Effects of Benzoyl Phenyl Urea on post-embryonic development in Pericallia ricini at different concentrations under different modes of treatment.

(Values are mean ± S.E.)

Mode of treatment	Concentration %	Pupation (%)	Larval pd. (days)	Emergence (%)	Pupal pd. (days)	Longevity (days)	
						Male	Female
PDM	.0001	83.33	16.50±0.24	66.00	11.20±012	9.88±0.12	13.98±0.10
	.001	71.66	17.30±0.28	62.79	12.33±016	9.80±0.22	13.70±0.24
	.01	65.00	18.42±0.16	56.41	13.38±0.10	8.88±0.26	11.78±0.36
	.10	58.33	20.00±0.34	45.71	14.66±0.26	7.28±0.30	9.86±0.22
	.50	50.00	21.20±0.12	40.00	17.66±0.32	6.48±0.16	7.30±0.16
	1.00	43.00	23.50±0.26	30.76	20.00±0.44	5.36±0.32	6.60±0.22
AFM	.0001	81.66	16.62±0.26	67.35	11.22±0.16	9.88±0.24	14.24±0.28
	.001	76.66	17.20±0.12	58.69	12.34±0.22	9.82±0.32	13.82±0.32
	.01	70.00	18.00±0.10	52.38	13.30±0.36	8.90±0.36	11.8±0.18
	.10	63.33	20.40±0.32	42.10	14.50±0.26	7.60±0.28	9.80±0.22
	.50	53.33	21.60±0.18	40.63	17.51±0.42	7.00±0.10	7.50±0.12
	1.00	41.66	23.24±0.36	32.00	19.92±0.30	6.00±0.26	6.50±0.34
RFM	.0001	83.33	16.28±0.28	68.00	11.20±0.10	10.42±0.23	13.82±0.32
	.001	76.66	17.10±0.22	63.33	12.33±0.24	9.88±0.28	13.76±0.20
	.01	65.00	17.90±0.26	53.85	13.00±0.30	9.00±0.22	11.80±0.42
	.10	58.33	17.90±0.26	48.57	14.24±0.18	8.00±0.32	9.72±0.12
	.50	56.66	20.80±0.36	41.18	17.33±0.32	7.00±0.20	8.00±0.36
	1.00	45.00	30.00±0.42	33.33	19.87±0.44	6.50±0.16	6.92±0.32
Control		83.33	15.00±0.34	100.00	11.64±0.21	11.48±0.16	14.30±0.32

TABLE - 17

Net mortality in <u>Pericallia</u> <u>ricini</u> Fab. caused by Diflubenzuron at different concentrations under different modes of treatment.

Mode of treatment	Concentration applied	No. larvae reared	No. larvae died	Pupae died (No.)	Total death(4+5)	%net mortality
1	2	3	4	5	6	7
PDM	.0001	60	20	16	36	52
	.001	60	26	23	49	78
	.01	60	33	19	52	84
	.10	60	38	16	54	88
	.50	60	41	15	56	92
	1.00	60	42	15	57	94
AFM	.0001	60	19	16	35	50
	.001	60	27	22	49	78
	.01	60	36	17	53	86
	.10	60	41	14	55	90
	.50	60	42	14	56	92
	1.00	60	43	14	57	94
RFM	.0001	60	18	14	32	44
	.001	60	25	23	48	76
	.01	60	31	19	50	80
	.10	60	36	17	53	86
	.50	60	38	16	54	86
	1.00	60	40	16	56	92
Control		60	10	Nil	10	---

TABLE -18

Net mortality in <u>Pericallia ricini</u> Fab. caused by Penfluron at different concentrations under different modes of treatment.

Mode of treatment	Concentration applied	No. larvae reared	No. larvae died	Pupae died (No.)	Total death(4+5)	%net mortlity
1	2	3	4	5	6	7
PDM	.0001	60	18	16	34	48
	.001	60	25	20	45	70
	.01	60	31	20	51	82
	.10	60	36	16	52	88
	.50	60	40	14	54	88
	1.00	60	41	14	55	90
AFM	.0001	60	18	15	33	46
	.001	60	26	19	45	70
	.01	60	32	15	47	74
	.10	60	37	15	52	84
	.50	60	40	14	54	88
	1.00	60	41	14	55	90
RFM	.0001	60	17	15	32	44
	.001	60	24	20	44	68
	.01	60	30	15	45	70
	.10	60	35	15	50	80
	.50	60	38	15	53	86
	1.00	60	40	14	54	88
Control		60	10	Nil	10	---

TABLE -19

Net mortality in Pericillia ricini Fab. caused by Diamino-furyl-s-triazine at different concentrations under different modes of treatment.

Mode of treatment	Concentration applied	No. larvae reared	No. larvae died	Pupae died (No.)	Total death(4+5)	%net mortality
1	2	3	4	5	6	7
PDM	.0001	60	17	16	33	46
	.001	60	23	21	44	67
	.01	60	31	17	48	76
	.10	60	35	16	51	82
	.50	60	39	15	55	88
	1.00	60	40	16	56	92
AFM	.0001	60	17	15	32	44
	.001	60	24	20	44	68
	.01	60	30	17	47	74
	.10	60	34	17	51	82
	.50	60	40	14	54	88
	1.00	60	41	15	56	92
RFM	.0001	60	16	15	31	42
	.001	60	23	20	43	66
	.01	60	27	19	46	72
	.10	60	36	14	50	80
	.50	60	37	15	52	84
	1.00	60	36	16	55	90
Control		60	10	Nil	10	----

TABLE - 20

Net mortality in <u>Pericallia ricini</u> Fab. caused by Benzoyl Phenyl Urea at different concentrations under different modes of treatment.

Mode of treatment	Concentration applied	No. larvae reared	No. larvae died	Pupae died (No.)	Total death(4+5)	%net mortlity
1	2	3	4	5	6	7
PDM	.0001	60	10	17	27	34
	.001	60	27	16	33	46
	.01	60	21	17	38	56
	.10	60	30	18	48	76
	.50	60	32	19	51	82
	1.00	60	34	18	52	84
AFM	.0001	60	11	16	27	34
	.001	60	14	19	33	46
	.01	60	18	20	38	56
	.10	60	22	22	44	68
	.50	60	28	19	47	74
	1.00	60	35	17	52	84
RFM	.0001	60	10	16	26	32
	.001	60	14	17	31	42
	.01	60	21	18	39	58
	.10	60	25	18	43	66
	.50	60	26	20	46	72
	1.00	60	33	18	51	82
Control		60	10	Nil	10	---

TABLE - 21

Effect of Diflubenzuron on reproductive periods in _Pericallia ricini_ Fab.

(Values are mean ± S.E.)

Mode of treatment	Concentration (%)	Pre-oviposition period (days)	Oviposition period (days)
PDM	.0001	3.00±0.13	8.14±0.23
	.001	3.08±0.11	8.00±0.12
	.01	3.04±0.14	7.12±0.22
	.10	3.92±0.26	4.36±0.24
	.50	3.96±0.23	3.32±0.32
	1.00	3.91±0.14	1.46±0.26
AFM	.0001	3.00±0.14	8.00±0.10
	.001	3.06±0.12	7.68±0.11
	.01	3.05±0.14	6.24±0.23
	.10	3.82±0.16	5.12±0.25
	.50	3.80±0.17	3..35±0.14
	1.00	3.84±0.72	1.57±0.26
RFM	.0001	3.02±0.21	9.27±0.26
	.001	3.12±0.23	8.96±0.18
	.01	3.05±0.14	8.23±0.17
	.10	3.72±0.13	7.06±0.19
	.50	3.76±0.14	5.11±0.11
	1.00	3.79±0.19	2.68±0.19
Control	----	1.20±0.22	4.06±0.33

TABLE- 22

Effect of Penfluron on reproductive periods in Pericallia ricini Fab.

(Values are mean ± S.E.)

Mode of treatment	Concentration (%)	Pre-oviposition period (days)	Oviposition period (days)
PDM	.0001	3.14±0.12	7.26±0.26
	.001	3.15±0.13	7.15±0.16
	.01	3.26±0.14	5.26±0.21
	.10	3.32±0.15	4.17±0.12
	.50	3.33±0.16	3.32±0.17
	1.00	3.83±0.15	1.72±0.16
AFM	.0001	3.18±0.21	7.64±0.27
	.001	3.14±0.22	7.25±0.26
	.01	3.25±0.17	5.87±0.17
	.10	3.31±0.22	4.11±0.12
	.50	3.32±0.21	3.06±0.11
	1.00	3.84±0.16	1.89±0.25
RFM	.0001	3.13±0.11	7.59±0.10
	.001	3.06±0.14	7.42±0.26
	.01	3.25±0.16	6.24±0.44
	.10	3.52±0.26	5.17±0.14
	.50	3.37±0.16	3.32±0.11
	1.00	3.77±0.17	2.46±0.12
Control	---	1.20±0.22	4.06±0.33

TABLE - 23

Effect of Diamino furyl-s-triazine on reproductive periods in _Pericillia ricini_ Fab.

(Values are mean ± S.E.)

Mode of treatment	Concentration (%)	Pre-oviposition period (days)	Oviposition period (days)
PDM	.0001	3.00±0.14	8.23±0.36
	.001	3.06±014.	7.84±0.25
	.01	3.22±0.13	6.52±0.14
	.10	3.25±0.16	5.26±0.13
	.50	3.30±0.12	4.44±0.14
	1.00	3.71±0.12	2.76±0.12
AFM	.0001	3.00±0.26	8.14±0.26
	.001	3.17±0.15	8.00±0.12
	.01	3.12±0.14	7.12±0.14
	.10	3.35±0.16	6.12±0.16
	.50	3.36±0.11	4.52±0.12
	1.00	3.72±0.12	2.32±0.13
RFM	.0001	3.00±0.25	8.25±0.37
	.001	3.16±0.14	8.14±0.17
	.01	3.14±0.13	6.24±0.14
	.10	3.34±0.14	4.35±0.17
	.50	3.35±0.11	3.22±0.12
	1.00	3.68±0.12	3.00±0.11
Control		1.20±0.22	4.06±0.33

TABLE 24

Effect of Benzoyl Phenyl Urea on reproductive periods in Pericillia ricini Fab.

(Values are mean ± S.E.)

Mode of treatment	Concentration (%)	Pre-oviposition period (days)	Oviposition period (days)
PDM	.0001	2.41±0.11	8.94±0.24
	.001	2.46±0.12	8.56±0.14
	.01	2.56±0.12	7.56±0.12
	.10	2.60±0.13	6.96±0.16
	.50	2.89±0.12	5.12±0.11
	1.00	3.00±0.12	3.50±0.12
AFM	.0001	2.50±0.12	8.90±0.23
	.001	2.52±0.14	8.40±0.22
	.01	2.56±0.16	7.22±0.22
	.10	2.70±0.18	6.24±0.16
	.50	2.73±0.11	5.12±0.12
	1.00	3.40±0.14	3.00±0.11
RFM	.0001	2.20±0.12	8.92±0.12
	.001	2.25±0.12	8.60±0.11
	.01	2.31±0.12	7.84±0.11
	.10	2.40±0.11	6.50±0.11
	.50	2.54±0.12	5.60±0.16
	1.00	3.00±0.12	3.64±0.12
Control		1.20±0.22	4.06±0.33

TABLE - 25

Effect of Diflubenzuron on fecundity and fertility in <u>Pericillia</u> <u>ricini</u> Fab.

(Values are mean ± S.E.)

Mode of treatment	Concentration (%)	No. eggs laid by a female	No. eggs hatched	% hatching	Incubation period (days)
PDM	.0001	226±4.69	194.8±3.82	86.2	3.97±0.16
	.001	224.8±5.32	191.3±3.60	85.2	4.00±0.18
	.01	221.2±3.72	182.1±4.32	83.2	4.55±0.12
	.10	1.66.2±5.47	113.5±3.46	68.3	5.46±0.12
	.50	119.9±4.75	77.1±4.21	64.3	6.50±0.11
	1.00	77.4±6.81	25.8±2.11	33.3	7.25±0.12
AFM	.0001	224.1±3.78	180.4±3.67	80.5	4.21±0.11
	.001	223.2±6.25	168.7±4.10	75.6	4.75±0.11
	.01	200.0±2.36	140.4±4.02	70.2	5.25±0.12
	.10	155.1±6.17	103.0±3.06	66.4	6.00±0.21
	.50	109.0±4.34	65.5±2.80	61.0	6.75±0.26
	1.00	56.2±3.46	8.3±1.32	14.8	7.88±0.28
RFM	.0001	225.1±4.44	194.7±3.80	86.5	3.86±0.12
	.001	226.6±4.34	191.4±4.67	85.6	3.96±0.12
	.01	222.0±3.62	178.5±3.46	80.4	4.30±0.14
	.10	19832±5.37	133.4±2.42	67.3	5.30±0.12
	.50	143.6±2.26	86.4±3.82	60.2	6.34±0.14
	1.00	110.8±4.14	42.5±2.92	38.4	6.87±0.14
Control		356.0±0.98	324.0±1.12	91.0	3.08±0.16

TABLE - 26

Effect of Penfluron on fecundity and fertility in _Pericallia ricini_ Fab.

(Values are mean ± S.E.)

Mode of treatment	Concentration (%)	No. eggs laid by a female	No. eggs hatched	% hatching	Incubation period (days)
PDM	.0001	258.4±3.50	226.1±3.42	89.5	3.50±0.11
	.001	247.3±3.46	208.5±4.12	84.3	3.75±0.11
	.01	210.0±8.12	170.5±3.86	81.2	4.00±0.10
	.10	175.4±5.14	118.6±6.40	67.6	4.74±0.10
	.50	125.3±4.40	76.7±2.60	61.2	5.51±0.10
	1.00	81.4±4.14	30.9±1.80	38.0	6.80±0.17
AFM	.0001	223.8±8.44	179.9±4.20	80.4	3.66±0.11
	.001	225.2±7.14	176.1±3.72	78.2	4.00±0.14
	.01	181.2±6.12	131.6±4.36	72.6	4.82±0.12
	.10	146.1±1.14	98.8±1.12	67.6	5.24±0.14
	.50	122.2±2.06	60.4±2.42	49.4	6.14±0.16
	1.00	68.4±4.10	12.0±0.80	17.4	7.92±0.15
RFM	.0001	260.4±5.37	225.5±5.12	86.6	3.45±0.17
	.001	251.3±3.48	214.6±3.80	85.4	3.62±0.12
	.01	212.7±8.11	170.6±4.67	80.2	3.92±0.12
	.10	180.6±4.42	123.5±3.42	68.4	4.50±0.11
	.50	131.7±5.38	80.7±2.64	61.3	5.30±0.12
	1.00	140.6±4.36	59.9±1.86	42.6	6.50±0.12
Control		356.0±0.98	324.0±1.12	91.0	3.08±0.16

TABLE - 27

Effect of Diamino furyl-s-triazine on fecundity and fertility in *Pericallia ricini* Fab.

(Values are mean $\pm$ S.E.)

Mode of treatment	Concentration (%)	No. eggs laid by a female	No. eggs hatched	% hatching	Incubation period (days)
PDM	.0001	250.0±4.74	218.0±4.44	87.2	3.65±0.12
	.001	241.4±3.75	203.0±3.40	84.4	4.00±0.11
	.01	220.0±8.76	172.7±5.26	78.5	4.64±0.12
	.10	180.0±6.04	123.8±4.64	68.8	5.00±0.11
	.50	130.6±5.44	65.3±2.12	50.0	5.54±0.26
	1.00	78.0±3.30	28.5±2.14	36.6	6.24±0.37
AFM	.0001	220.0±4.12	176.7±4.10	80.3	4.00±0.11
	.001	210.0±3.25	168.0±3.00	80.0	4.72±0.12
	.01	178.5±3.46	125.0±4.80	70.0	5.00±0.14
	.10	150.6±8.11	84.8±4.11	56.3	5.42±0.12
	.50	136.4±3.14	55.0±2.00	40.3	5.84±0.12
	1.00	70.1±1.11	13.6±1.14	19.3	6.35±0.17
RFM	.0001	261.3±2.34	227.9±3.40	87.2	3.72±0.12
	.001	251.4±5.12	207.2±4.12	84.2	3.94±0.14
	.01	231.2±3.71	183.3±5.60	79.3	4.63±0.12
	.10	182.4±8.20	110.0±2.00	60.3	4.97±0.12
	.50	141.2±6.90	74.1±2.70	52.5	5.32±0.14
	1.00	136.4±3.30	56.5±1.40	41.4	6.00±0.23
Control		356.0±0.98	324.0±1.12	91.0	3.08±0.16

TABLE - 28

Effect of Benzoyl Phenyl Urea on fecundity and fertility in _Pericallia ricini_ Fab.

(Values are mean ± S.E.)

Mode of treatment	Concentration (%)	No. eggs laid by a female	No. eggs hatched	% hatching	Incubation period (days)
PDM	.0001	262.4±4.63	206.4±3.42	78.7	3.12±0.15
	.001	248.3±3.24	176.8±5.10	71.2	3.26±0.14
	.01	230.6±6.14	150.6±4.22	65.3	3.30±0.12
	.10	212.4±4.26	128.3±6.10	60.4	3.34±0.11
	.50	170.5±3.33	71.1±2.42	45.2	3.75±0.13
	1.00	108.0±2.22	43.2±1.46	40.0	4.71±0.12
AFM	.0001	245.4±4.34	192.9±3.46	78.6	3.23±0.12
	.001	234.6±2.34	167.3±5.13	71.3	3.30±0.14
	.01	220.4±3.68	137.5±4.76	62.4	3.40±0.12
	.10	185.4±2.14	104.2±6.06	56.2	3.43±0.13
	.50	135.2±3.46	53.7±3.12	39.7	3.76±0.14
	1.00	98.7±2.22	30.8±1.46	31.2	4.79±0.16
RFM	.0001	257.3±2.13	202.8±3.42	78.8	3.12±0.13
	.001	2.45.4±3.23	175.2±5.56	71.4	3.19±0.12
	.01	201.3±4.46	133.5±4.40	66.3	3.40±0.11
	.10	182.5±2.35	113.7±5.10	62.3	3.46±0.12
	.50	143.6±5.26	62.2±3.43	43.3	3.70±0.14
	1.00	110.3±3.30	37.9±2.10	34.4	4.60±0.10
Control		356.0±0.98	324.9±1.12	91.0	3.08±0.16

TABLE - 29

Per cent reduction in fecundity, per cent net sterility and per cent control over reproduction in _Pericallia ricini_ Fab. caused by Diflubenzuron under different modes of treatment.

Mode of treatment	Concentration (%)	% reduction in fecundity	% net sterility	% control over reproduction
PDM	.0001	36.52	5.26	39.88
	.001	36.85	6.37	40.96
	.01	.37.84	8.57	43.80
	.10	53.32	24.34	64.97
	.50	66.32	29.34	76.20
	1.00	78.26	63.41	92.03
AFM	.0001	37.05	11.54	44.32
	.001	37.30	16.92	47.93
	.01	43.82	22.86	56.67
	.10	53.62	25.93	65.65
	.50	69.38	32.97	79.48
	1.00	84.21	83.73	97.44
RFM	.0001	36.77	4.95	39.90
	.001	37.19	4.84	40.93
	.01	37.64	11.65	44.91
	.10	44.33	26.04	58.83
	.50	59.66	33.85	73.33
	1.00	69.88	57.80	86.88

TABLE - 30

Per cent reduction in fecundity, per cent net sterility and per cent control over reproduction in _Pericallia_ _ricini_ Fab. caused by Penfluron under different modes of treatment.

Mode of treatment	Concentration (%)	% reduction in fecundity	% net sterility	% control over reproduction
PDM	.0001	27.42	3.82	30.22
	.001	30.53	7.36	35.65
	.01	41.01	10.77	47.38
	.10	50.73	25.71	36.40
	.50	64.80	32.75	76.33
	1.00	77.14	58.24	90.46
AFM	.0001	37.13	11.65	44.48
	.001	36.74	14.07	45.65
	.01	49.10	20.11	59.38
	.10	58.96	25.71	69.51
	.50	65.67	45.71	81.36
	1.00	80.79	80.87	96.30
RFM	.0001	26.85	4.84	30.40
	.001	29.41	6.15	33.77
	.01	40.25	11.87	47.35
	.10	49.27	24.84	61.86
	.50	63.00	32.64	75.09
	1.00	60.51	53.08	81.85

TABLE - 31

Per cent reduction in fecundity, per cent net sterility and per cent control over reproduction in Pericallia ricini Fab. caused by Diamino-furyl-s-triazine under different modes of treatment.

Mode of treatment	Concentration (%)	% reduction in fecundity	% net sterility	% control over reproduction
PDM	.0001	29.78	4.18	32.72
	.001	32.19	7.25	37.13
	.01	38.20	13.74	46.70
	.10	49.44	24.40	61.79
	.50	63.22	45.06	79.85
	1.00	78.09	59.78	91.20
AFM	.0001	38.20	11.76	45.46
	.001	41.01	12.09	48.15
	.01	49.86	23.08	61.42
	.10	57.70	37.03	73.83
	.50	61.69	55.71	83.03
	1.00	80.34	78.79	95.80
RFM	.0001	26.60	3.29	29.66
	.001	29.38	7.47	36.05
	.01	35.06	12.85	43.43
	.10	48.76	33.74	66.05
	.50	60.37	42.31	77.13
	1.00	61.86	54.51	82.56

TABLE - 32

Per cent reduction in fecundity, per cent net sterility and per cent control over reproduction in _Pericallia ricini_ Fab. caused by Benzoyl Phenyl Urea under different modes of treatment.

Mode of treatment	Concentration (%)	% reduction in fecundity	% net sterility	% control over reproduction
PDM	.0001	26.32	13.52	36.30
	.001	32.50	21.76	45.43
	.01	35.23	28.24	53.52
	.10	4.034	33.63	60.40
	.50	52.11	50.33	76.20
	1.00	69.66	65.93	86.67
AFM	.0001	31.09	13.63	40.46
	.001	34.10	21.65	48.36
	.01	38.09	31.43	57.56
	.10	47.92	38.24	67.84
	.50	62.30	56.37	83.43
	1.00	72.28	65.71	90.49
RFM	.0001	27.72	13.40	37.41
	.001	31.07	21.54	45.93
	.01	43.46	27.14	58.80
	.10	48.74	31.54	64.91
	.50	59.66	52.42	80.80
	1.00	69.02	62.20	88.30

TABLE - 33

Sex specific effect of Diflubenzuron on reproduction in _Pericallia ricini_ Fab. (1 per cent Diflubenzuron applied by PDM for 1 minute only)

TR = Treated; UNT = Untreated; F = Female and M = Male

Mating between	No. Eggs laid (Mean ± S.E.)	No. Eggs hatched (Mean ± S.E.)	% Hatching	% Net Sterility
UNT F × TRM	89.2±5.78	37.91±2.80	42.4	53.41
TR F × UNTM	90.4±3.46	41.22±2.36	45.6	50.44
TR F × TRM	77.4±6.81	25.8±1.12	33.3	63.41
UNT F × UNTM (Control)	356±5.40	324±4.32	91.0	---

TABLE - 34

Sex specific effect of Penfluron on reproduction in _Pericallia ricini_ Fab. (1 per cent Penfluron applied by PDM for 1 minute only)

TR = Treated; UNT = Untreated; F = Female and M = Male

Mating between	No. Eggs laid (Mean ± S.E.)	No. Eggs hatched (Mean ± S.E.)	% Hatching	% Net Sterility
UNT F × TRM	91.0±4.42	39.5±3.10	43.3	52.4
TR F × UNTM	94.6±4.32	4.61±3.66	48.7	46.5
TR F × TRM	83.4±4.14	30.9±2.40	38.0	58.2
UNT F × UNTM (Control)	356±5.40	324±4.32	91.0	---

TABLE 35

Sex specific effect of Diamino-furyl-s-triazine on reproduction in _Pericallia ricini_ Fab. (1 per cent Diamino-furyl-s-triazine applied by PDM for 1 minute only)

TR = Treated; UNT = Untreated; F = Female and M = Male.

Mating between	No. Eggs laid (Mean ± S.E.)	No. Eggs hatched (Mean ± S.E.)	% Hatching	% Net Sterility
UNT F × TRM	92.4±4.37	39.0±3.40	42.2	53.63
TR F × UNTM	97.6±2.32	48.4±3.22	49.6	45.50
TR F × TRM	78.8±3.30	28.5±2.16	36.6	59.78
UNT F × UNTM (Control)	356±5.40	324±4.32	91.0	---

TABLE - 36

Sex specific effect of Benzoyl Phenyl Urea on reproduction in _Pericallia ricini_ Fab. (1 per cent Benzoyl Phenyl Urea by PDM for 1 minute only).

TR = Treated; UNT = Untreated; F = Female and M = Male.

Mating between	No. Eggs laid (Mean ± S.E.)	No. Eggs hatched (Mean ± S.E.)	% Hatching	% Net Sterility
UNT F × TRM	175.6±5.32	109.93±4.10	62.6	30.77
TR F × UNTM	190.6±4.88	138.38±3.68	72.6	31.11
TR F × TRM	108.0±2.22	43.20±2.60	40.0	57.14
UNT F × UNTM (Control)	356±5.40	324±4.32	91.0	----
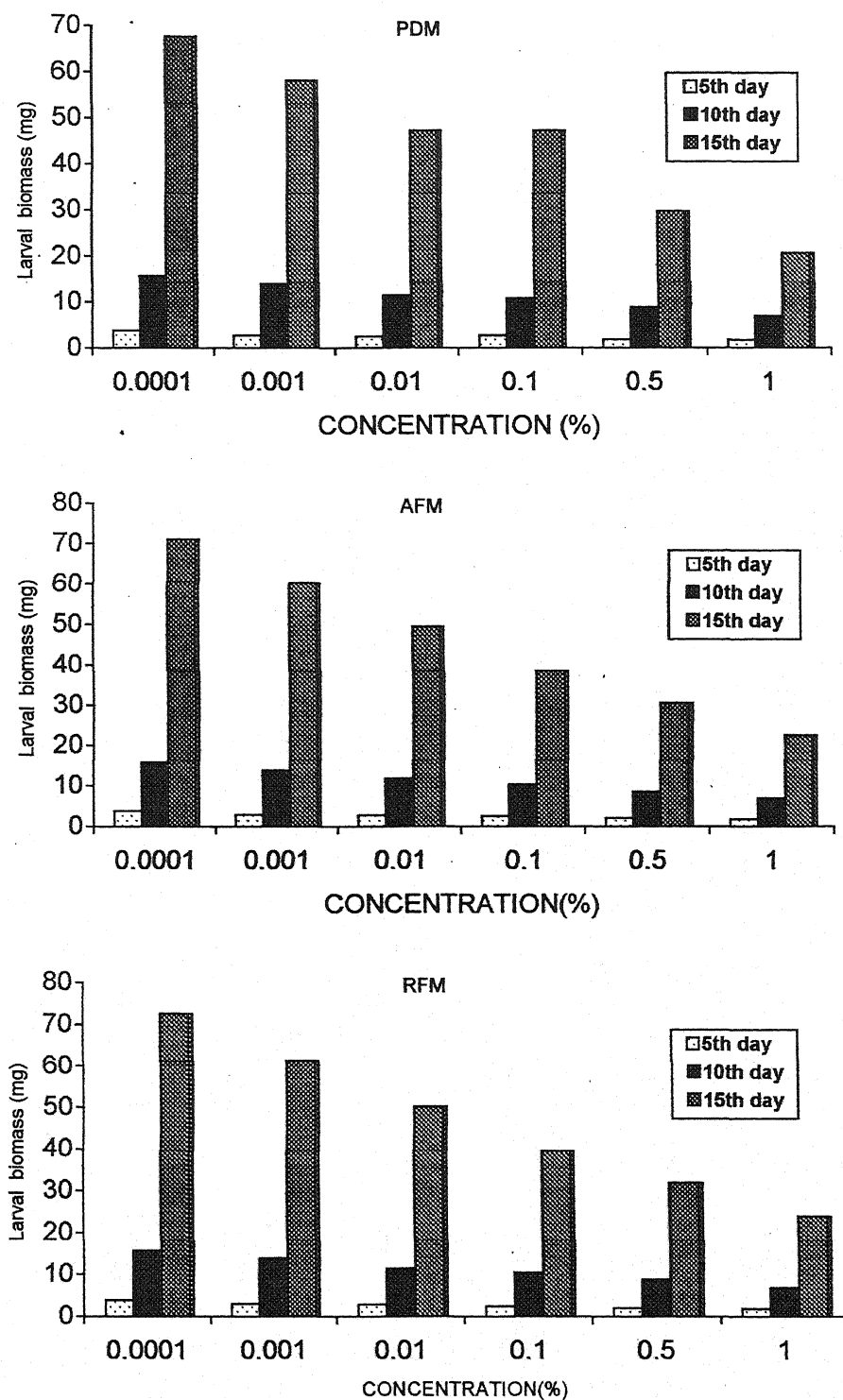
Fig. 1. Effect of different concentrations of Diflubenzuron under different modes of treatment on biomass accumulation in larvae of Pericallia ricini Fab.
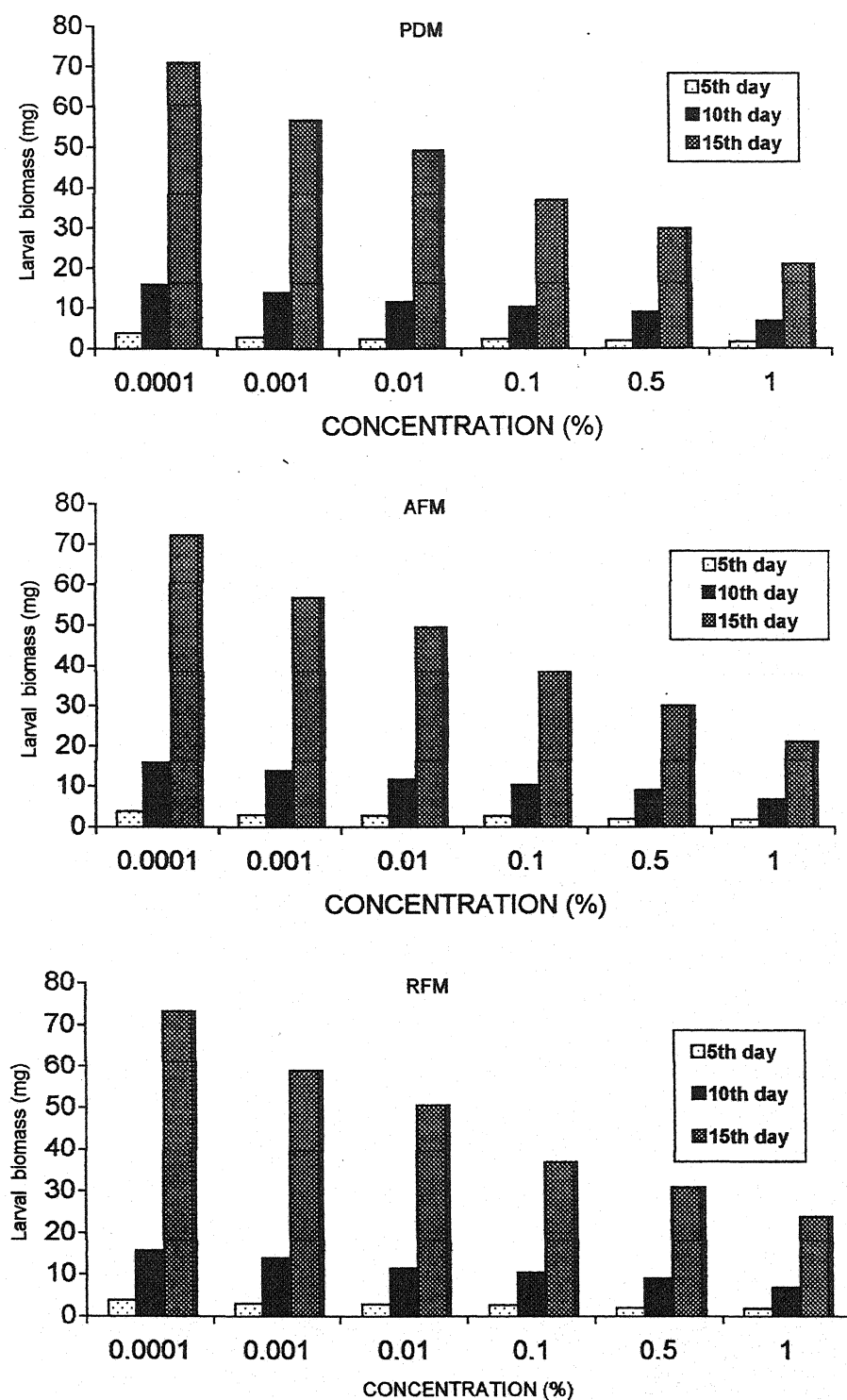
Fig. 2. Effect of different concentrations of Penfluron under different modes of treatment on biomass accumulation in larvae of Pericallia ricini Fab.
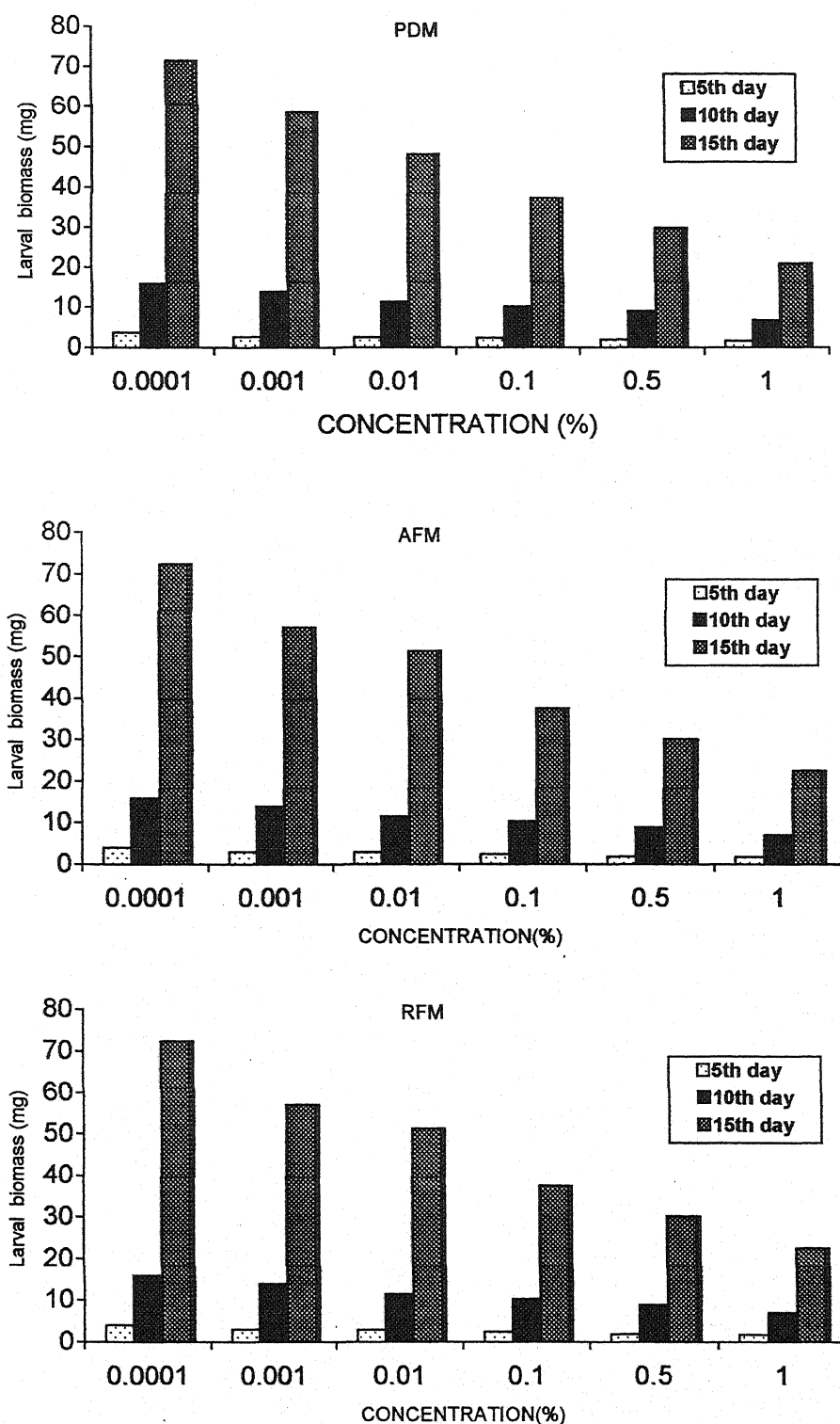
Fig. 3.Effect of different concentrations of Diamino-furyl-s-triazine under different modes of treatment on biomass accumulation in larvae of <u>Pericallia ricini</u> Fab.
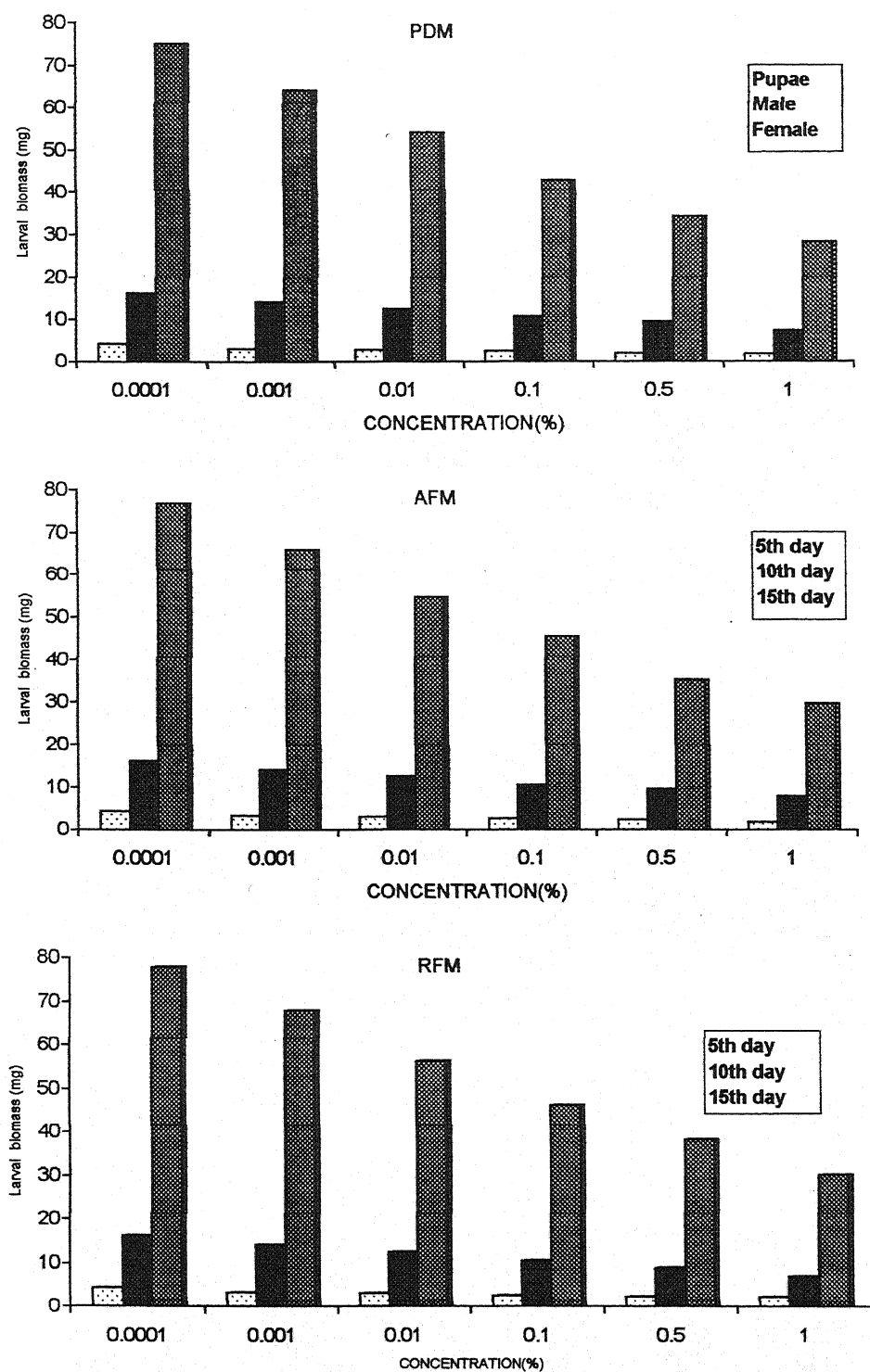
Fig. 4. Effect of different concentrations of Benzoyl Phenyl Urea under different modes of treatment on biomass accumulation in larvae of Pericallia ricini Fab.
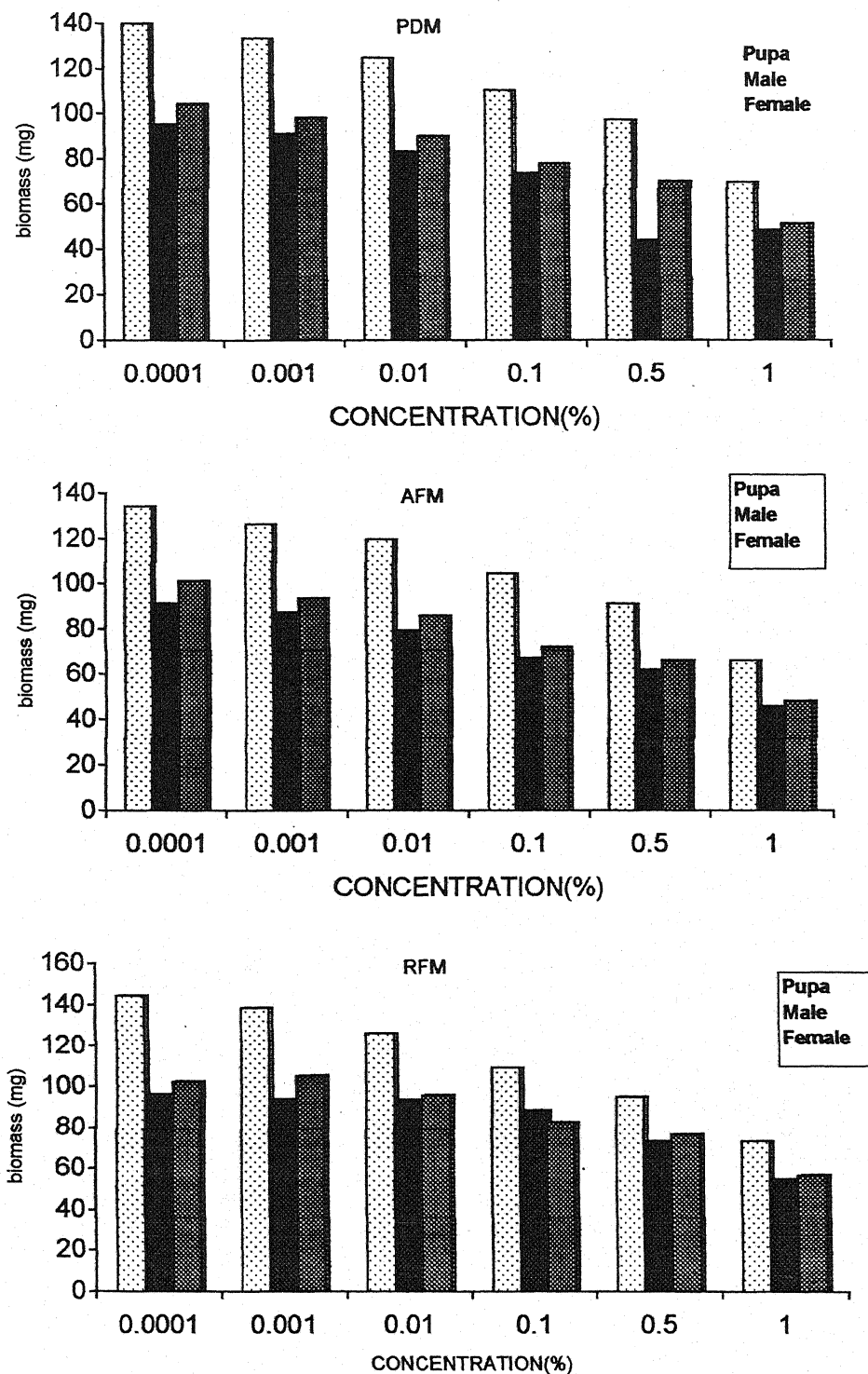
Fig. 5. Effect of Diflubenzuron at different concentrations under different modes of treatment on biomass accumulation by pupa and adults in Pericallia ricini Fab.
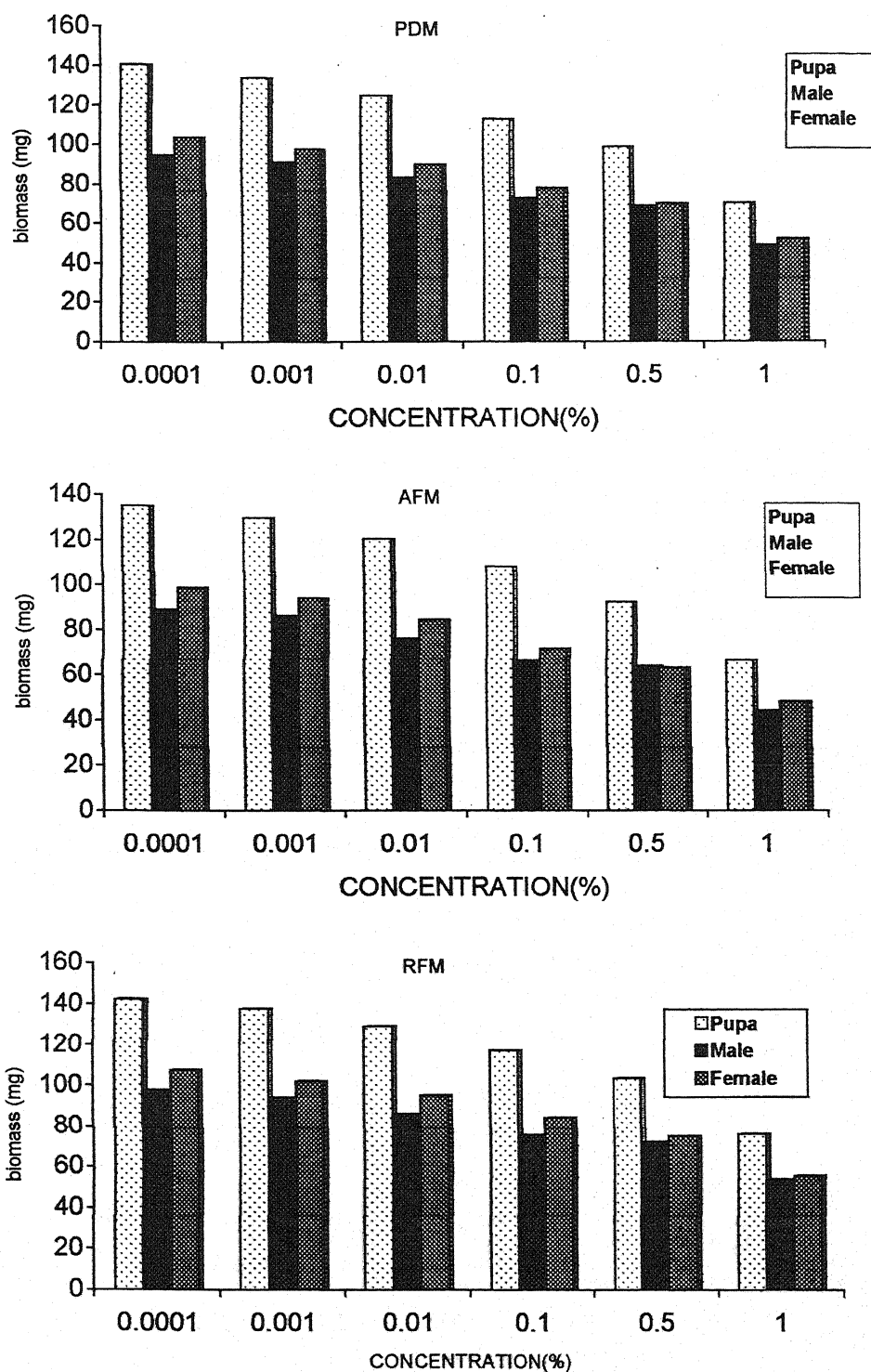
Fig. 6. Effect of Penfluron at different concentrations under different modes of treatment on biomass accumulation by pupa and adults in Pericallia ricini Fab.
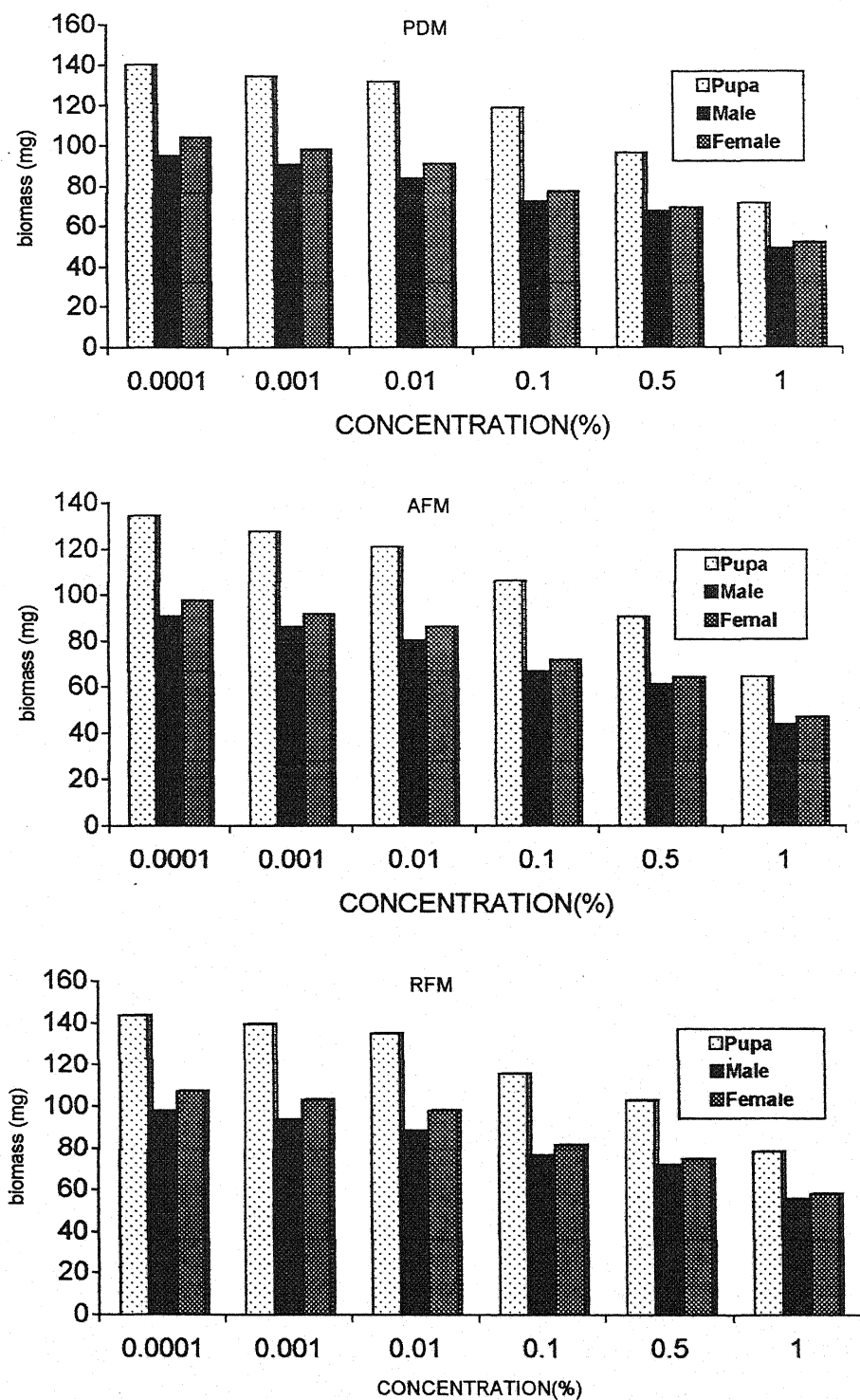
Fig. 7. Effect of Diamino-furyl-s-triazine at different concentrations under different modes of treatment on biomass accumulation by pupa and adults in Pericallia ricini Fab.
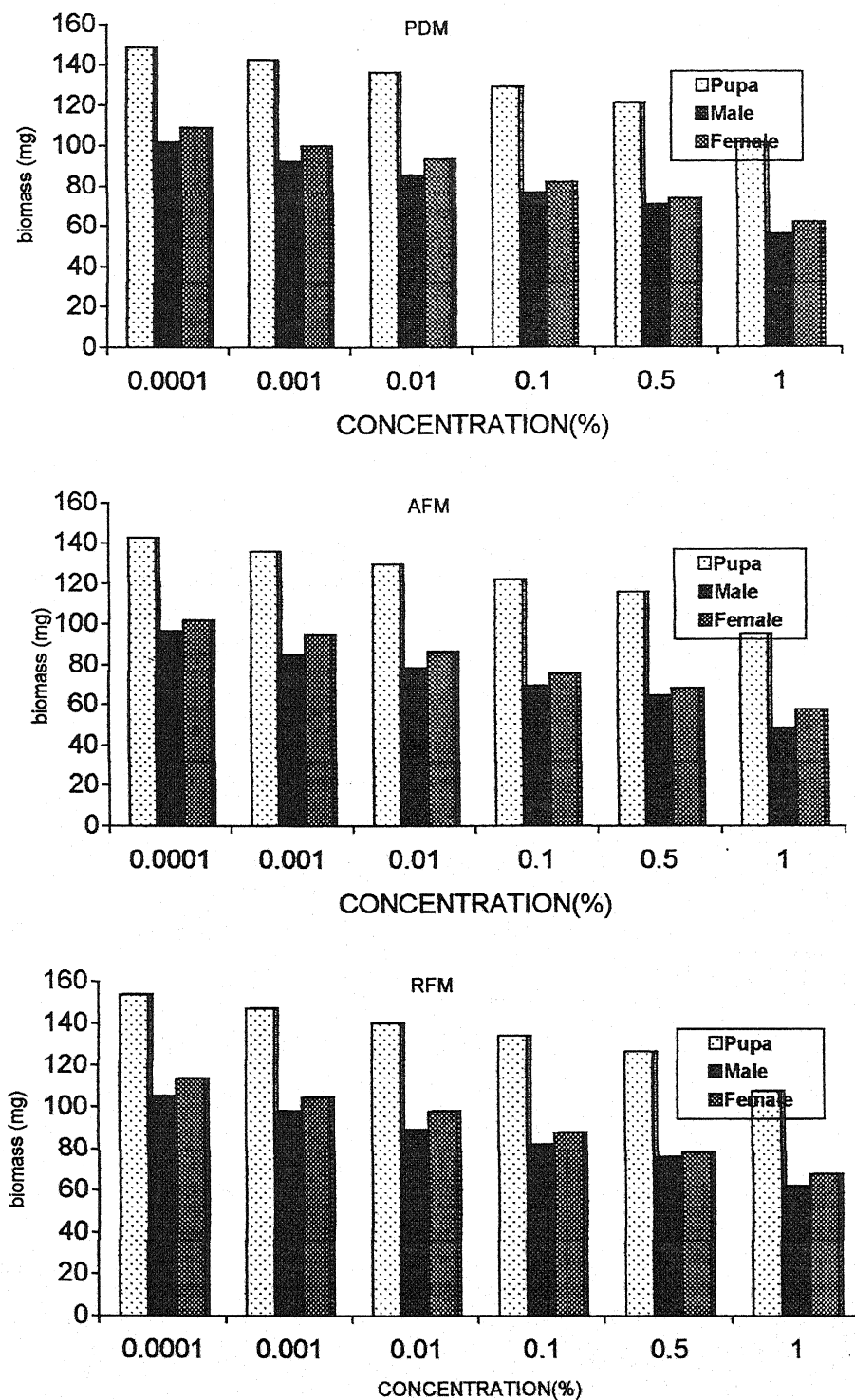
Fig. 8. Effect of Benzoyl Phenyl Urea at different concentrations under different modes of treatment on biomass accumulation by pupa and adults in Pericallia ricini Fab.
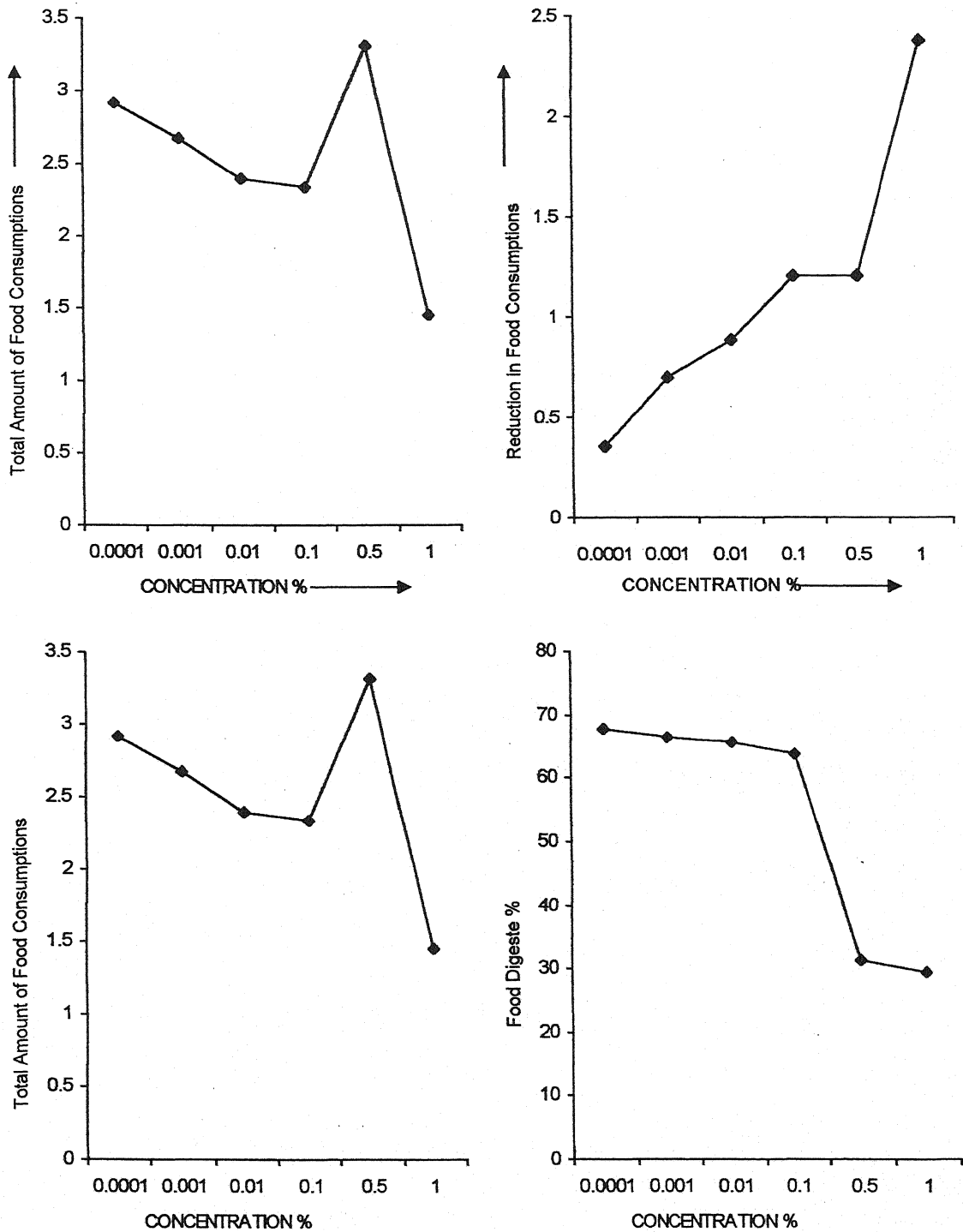
Fig. 9. Effect of Diflubenzuron on food consumption and faecal matter of <u>Pericallia ricini</u> larvae in larval feeding treatment.
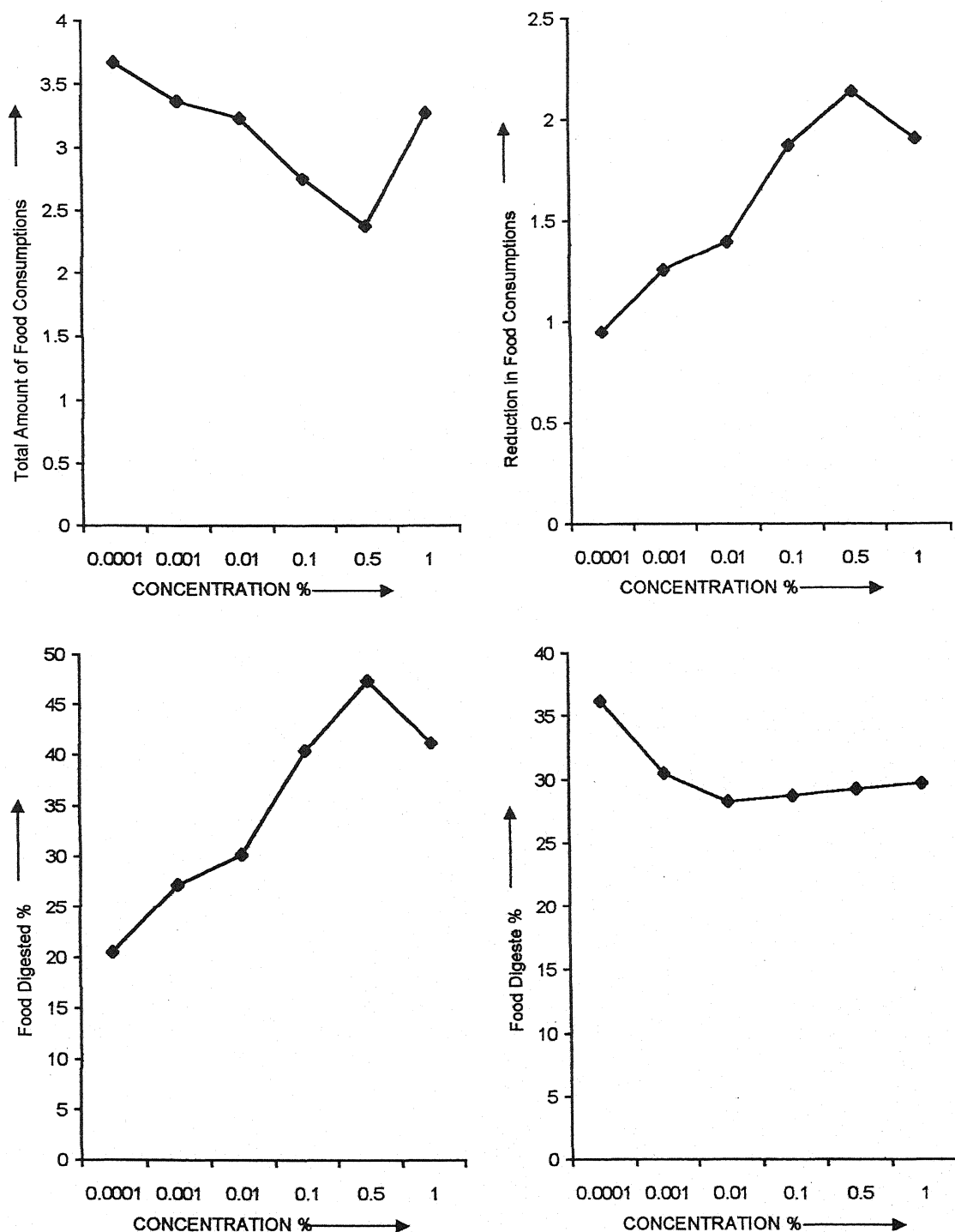
Fig. 10. Effect of Penfluron on food consumption and faecal matter of Pericallia ricini larvae in larval feeding treatment.
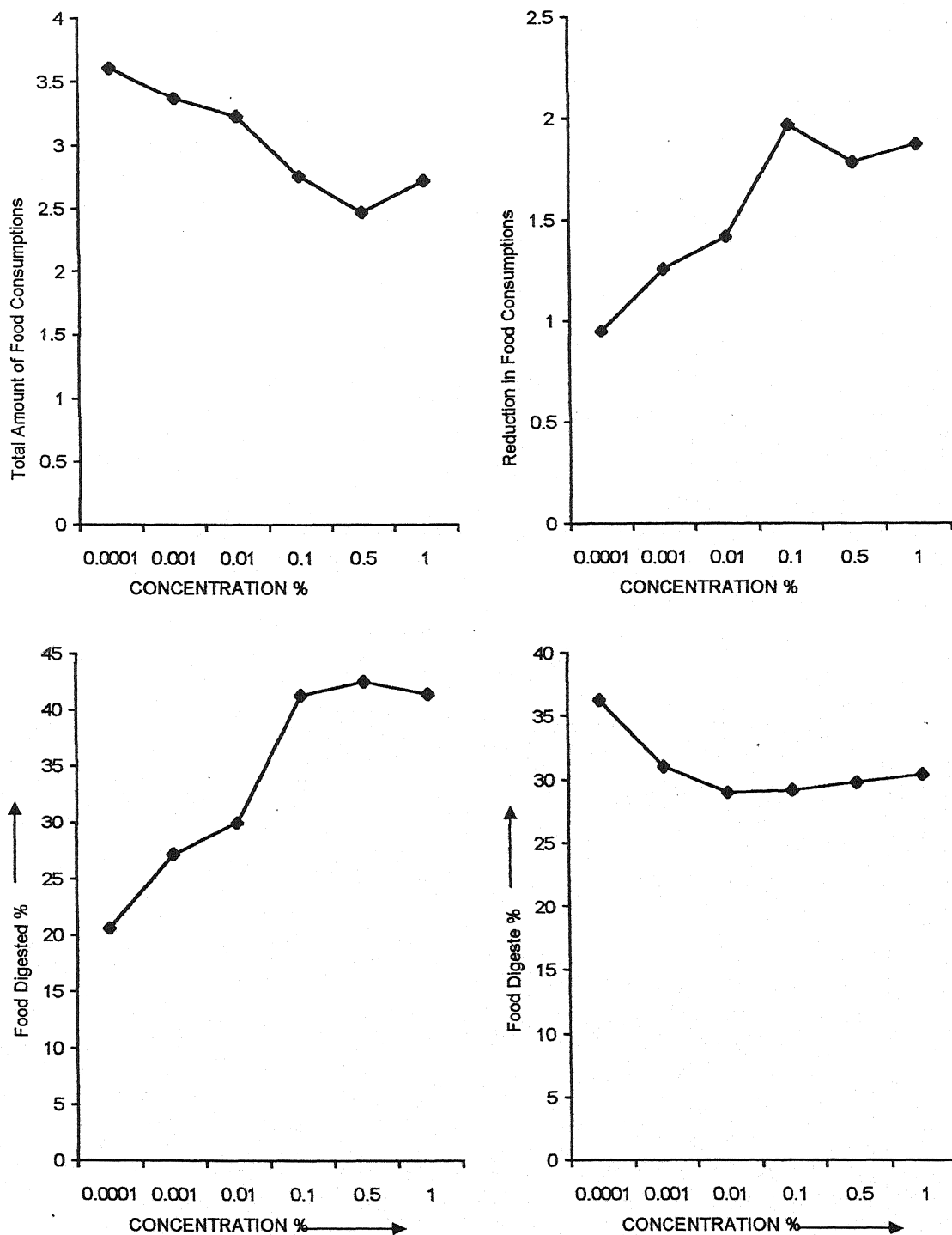
Fig. 11. Effect of Diamino-furyl-s-triazine on food consumption and faecal matter of Pericallia ricini larvae in larval feeding treatment
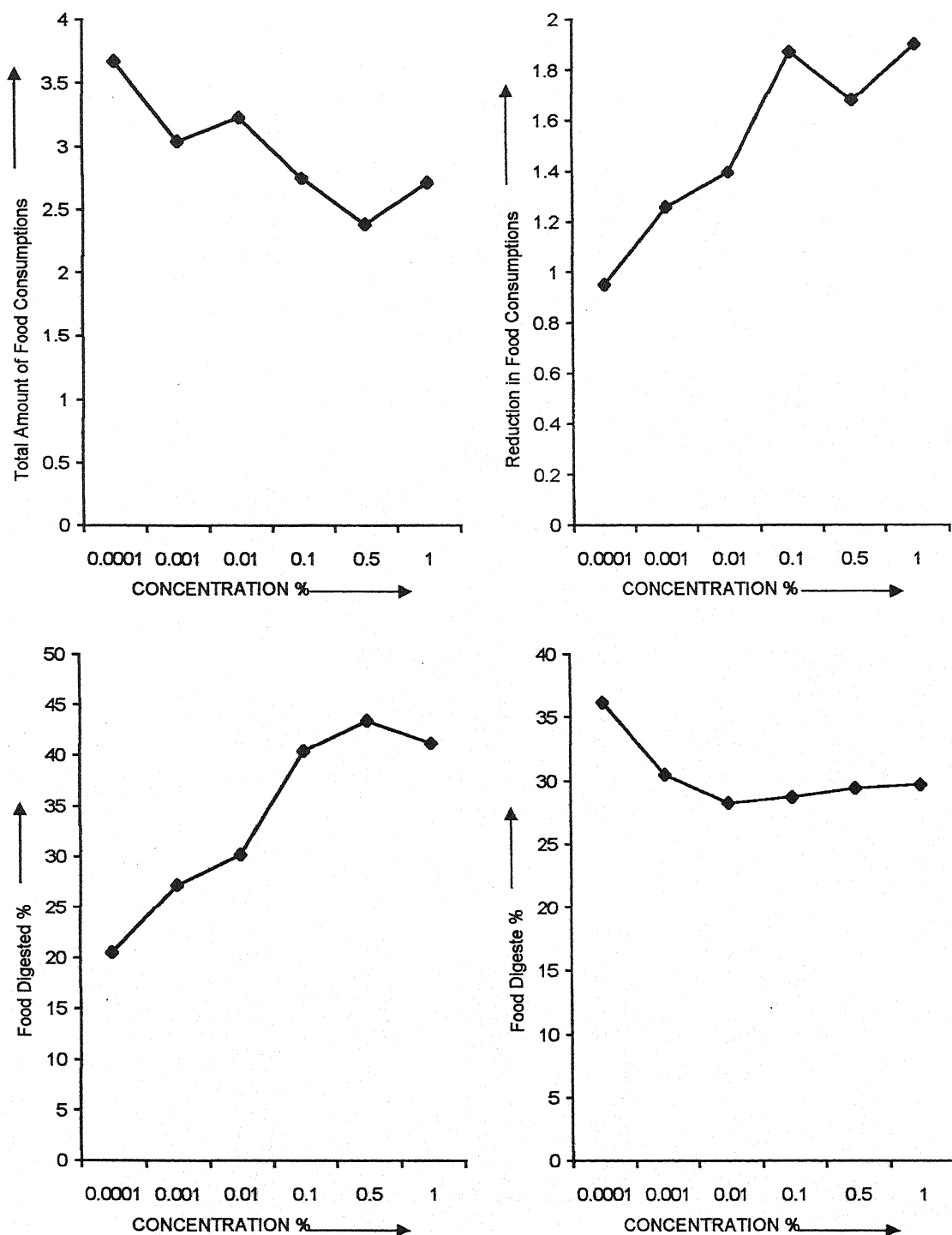
Fig. 12. Effect of Benzoyal Phenyl Urea on food consumption and faecal matter of Pericallia ricini larvae in larval feeding treatment
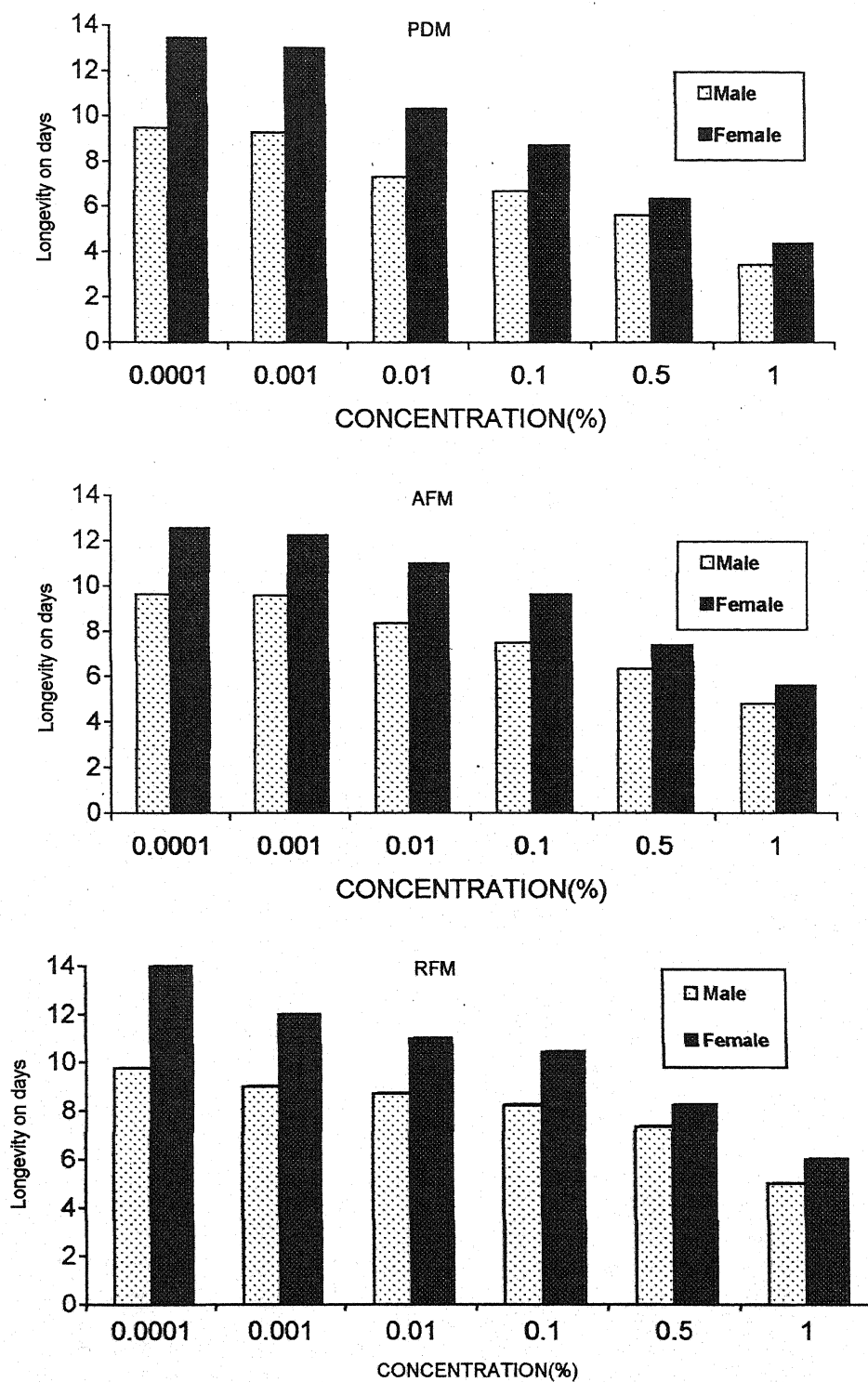
Fig. 13. Effects of Diflubenzron on longevity in Pericallia ricini at different concentrations under different modes of treatment.
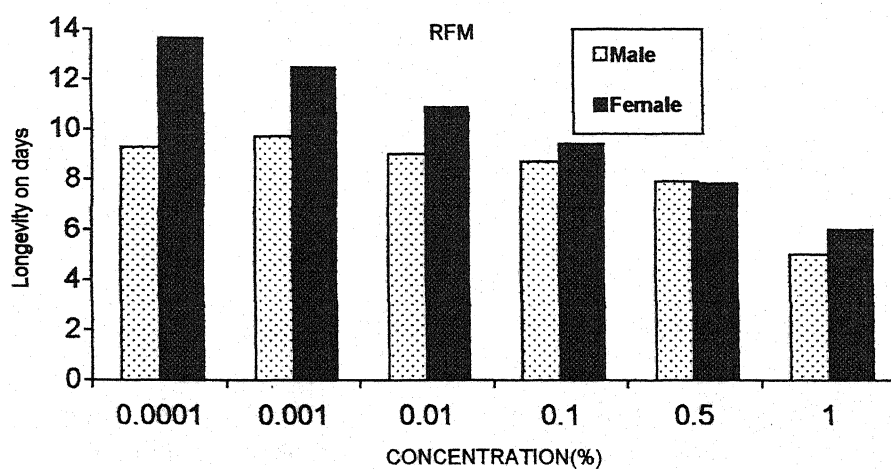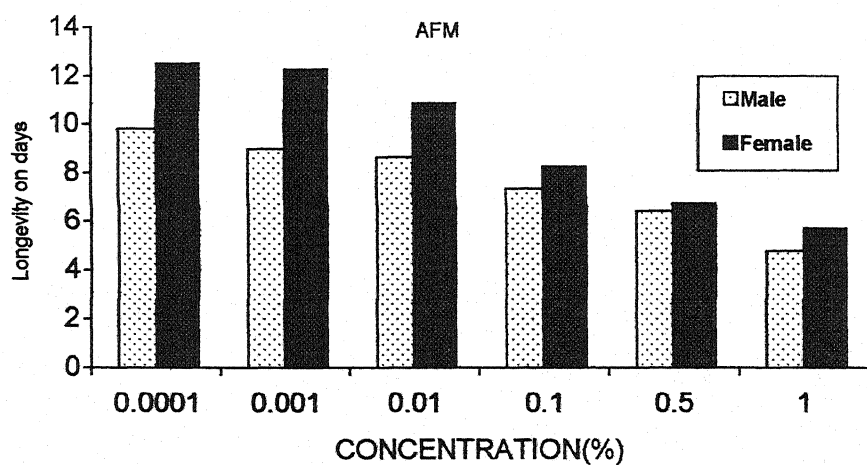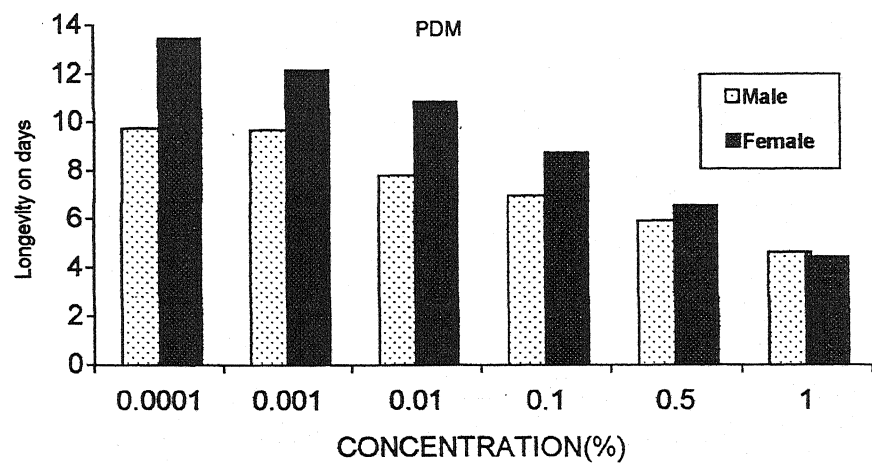
Fig. 14. Effects of Penfluron on longevity in Pericallia ricini at different concentrations under different modes of treatment.
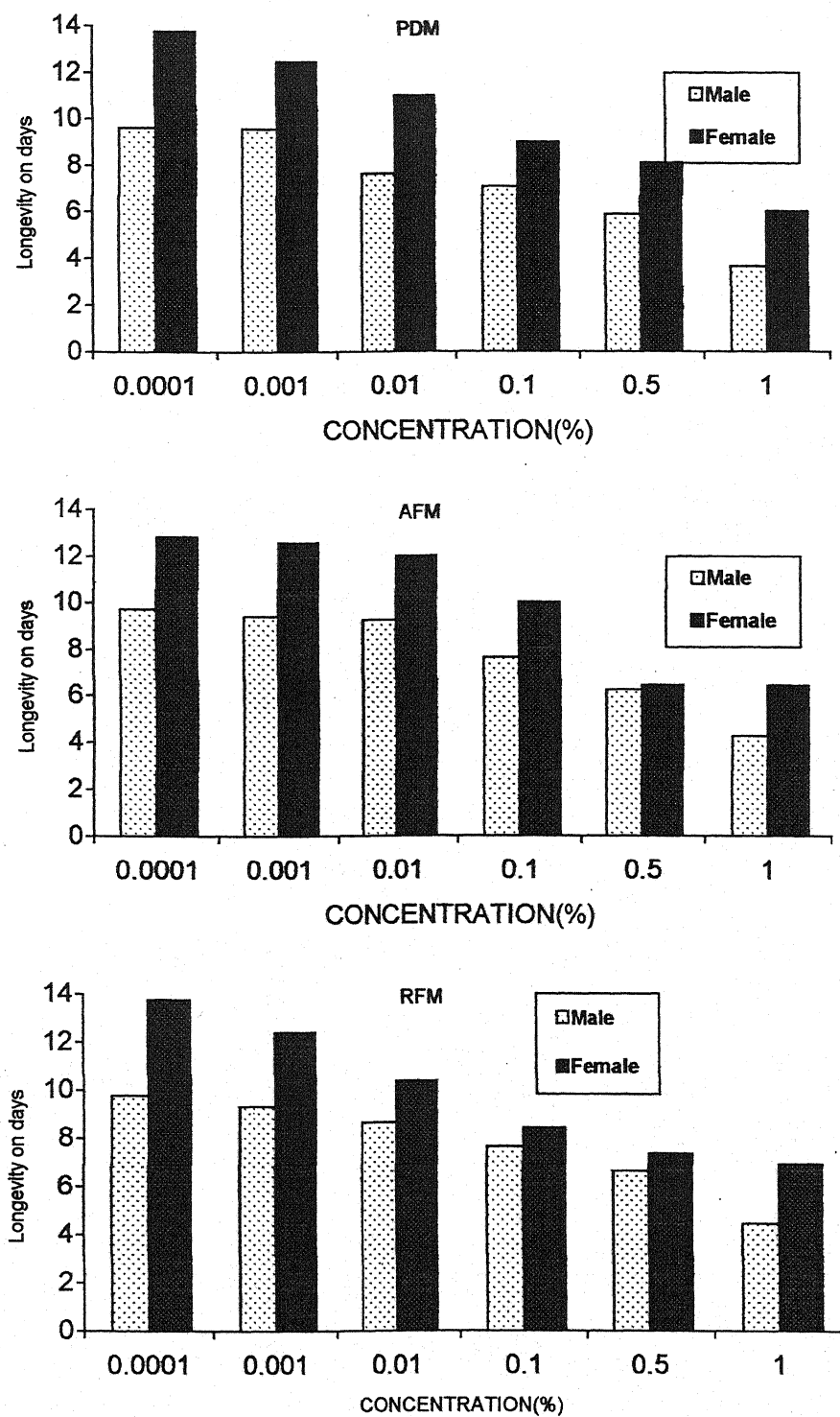
Fig.15. Effects of Diamino furyl-s-triazine on longevity in Pericallia ricini at different concentrations under different modes of treatment.
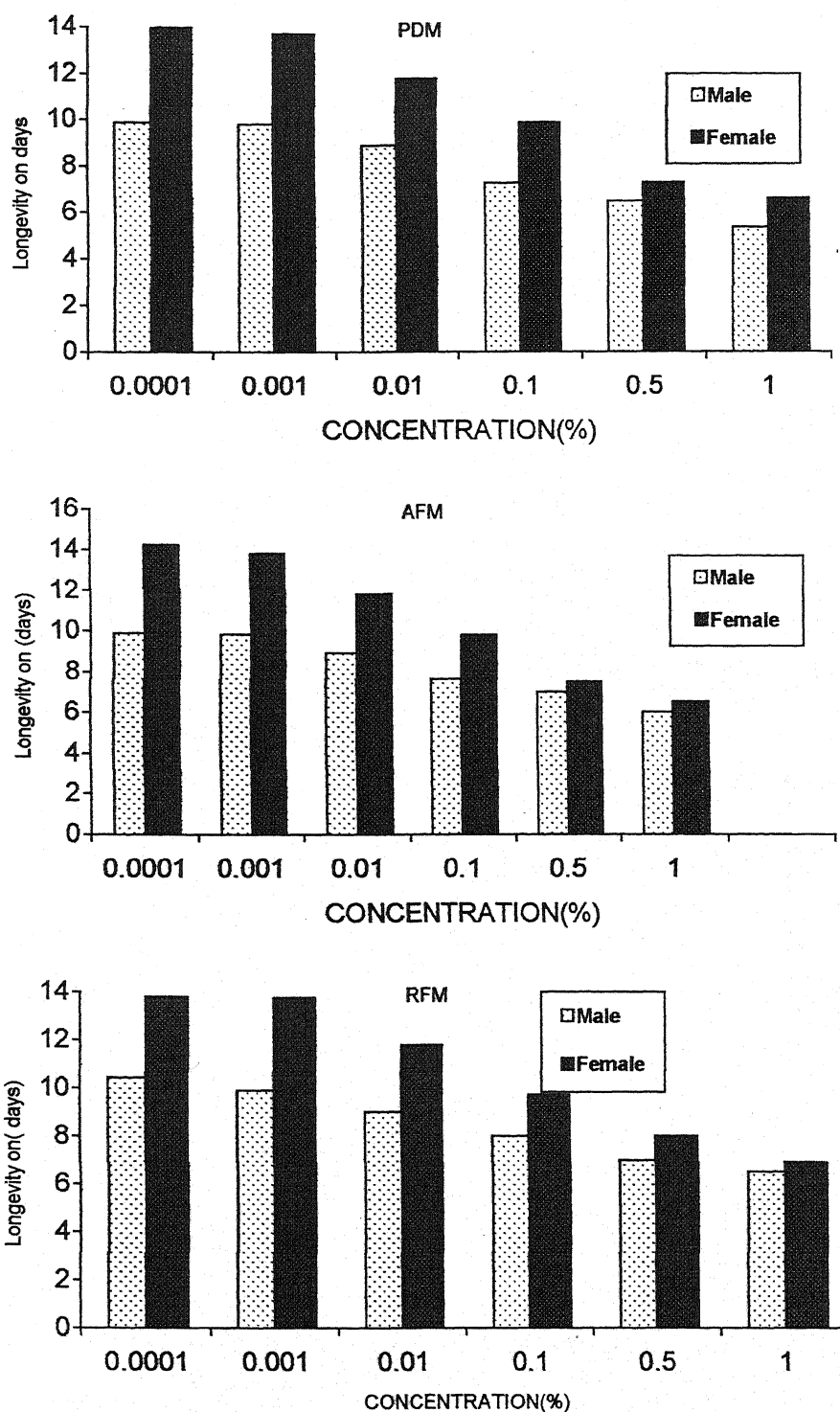
Fig. 16. Effects of Benzoyl Phenyl Urea on longevity in Pericallia ricini at different concentrations under different modes of treatment.
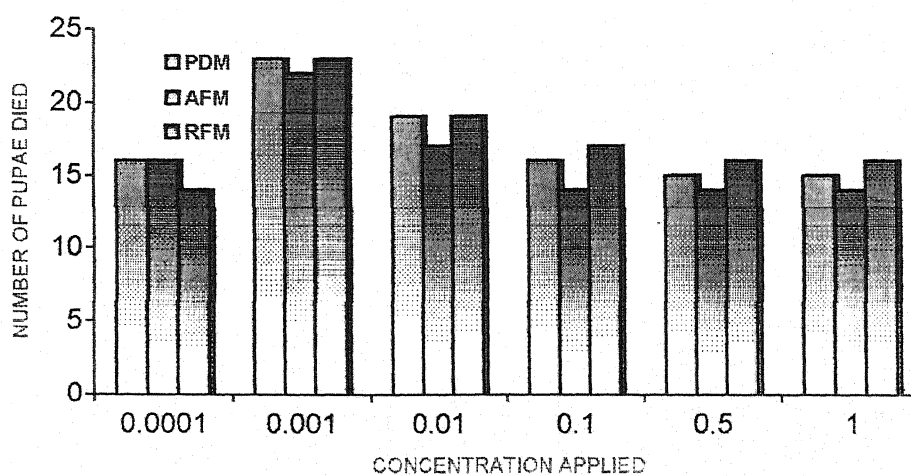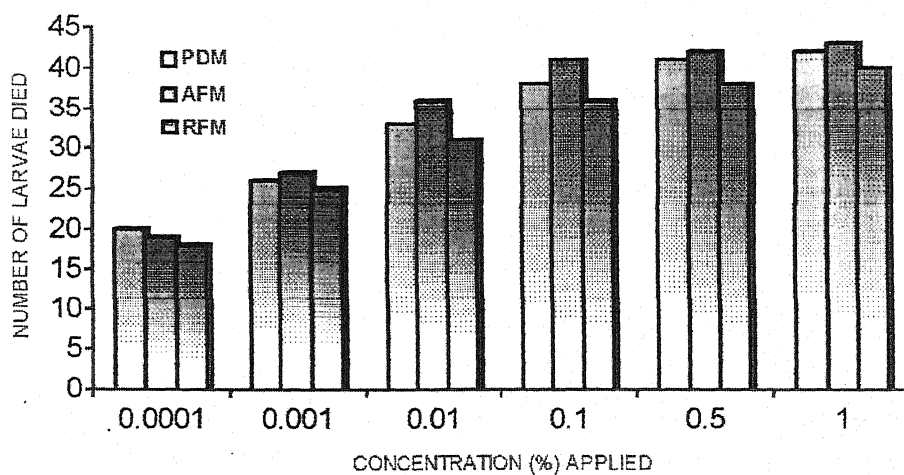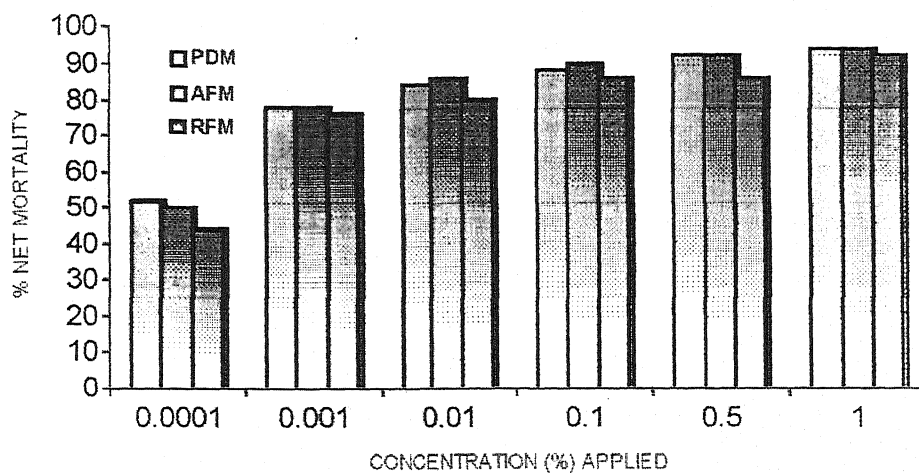
TABLE No. 17 : Net mortality in _Pericallia ricini_ Fab. caused by Diflubenzuron different concentrations under different modes of treatment.

% NET MORTALITY
0
10
20
30
40
50
60
70
80
90
PDM
AFM
RFM
0.0001
0.001
0.01
0.1
0.5
1
CONCENTRATION APPLIED
NUMBER OF LARVAE DIED
0
5
10
15
20
25
30
35
40
45
PDM
AFM
RFM
0.0001
0.001
0.01
0.1
0.5
1
CONCENTRATION APPLIED
NUMBER OF PUPAE DIED
0
2
4
6
8
10
12
14
16
18
20
PDM
AFM
0.0001
0.001
0.01
0.1
0.5
1
CONCENTRATION APPLIED
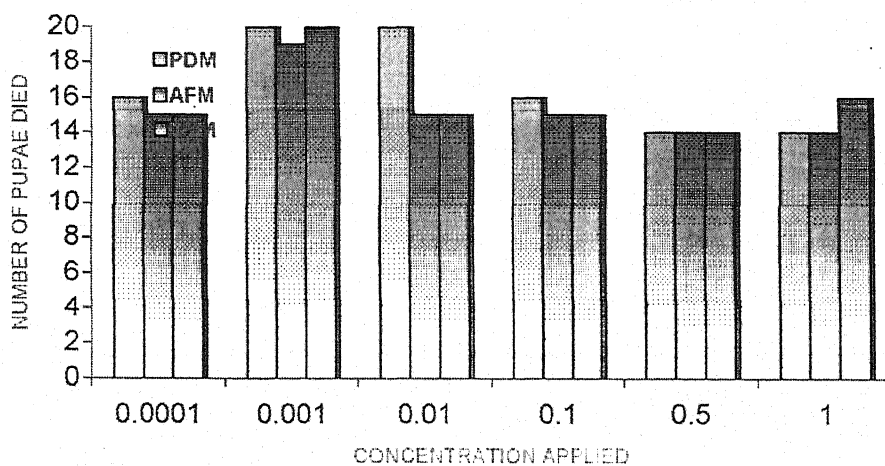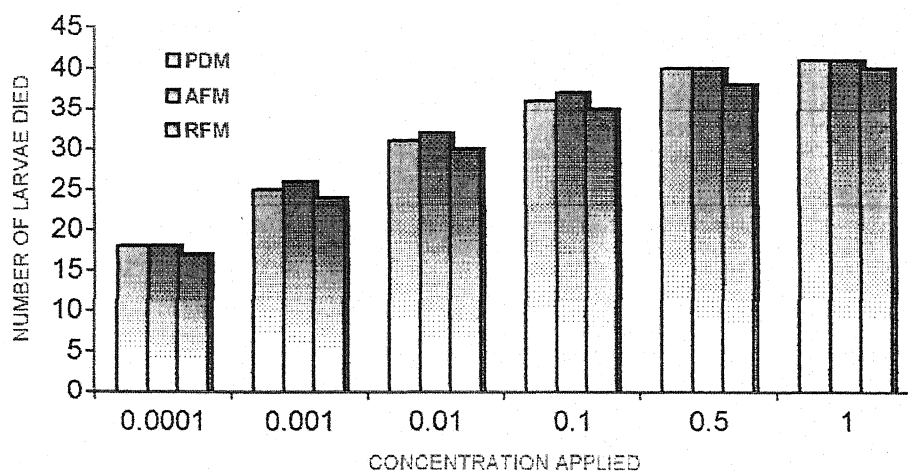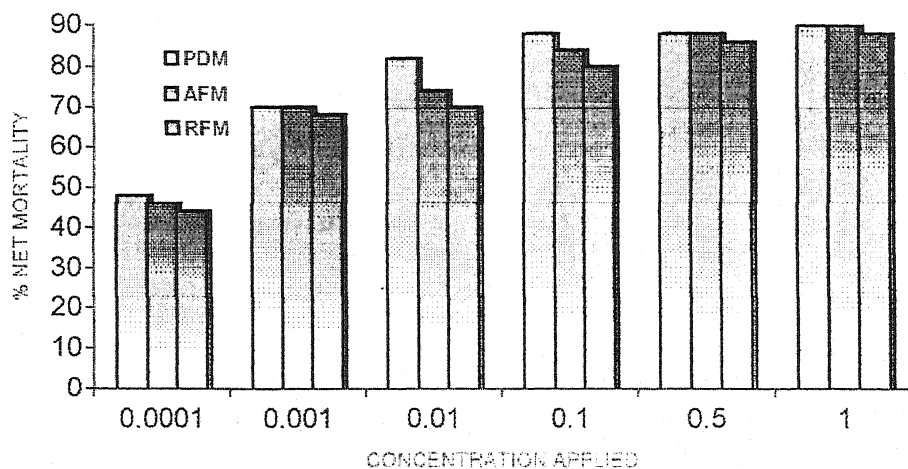
TABLE No. 18 : Net mortality in Pericallia ricini Fab. caused by Penfluron different concentrations under different modes of treatment.
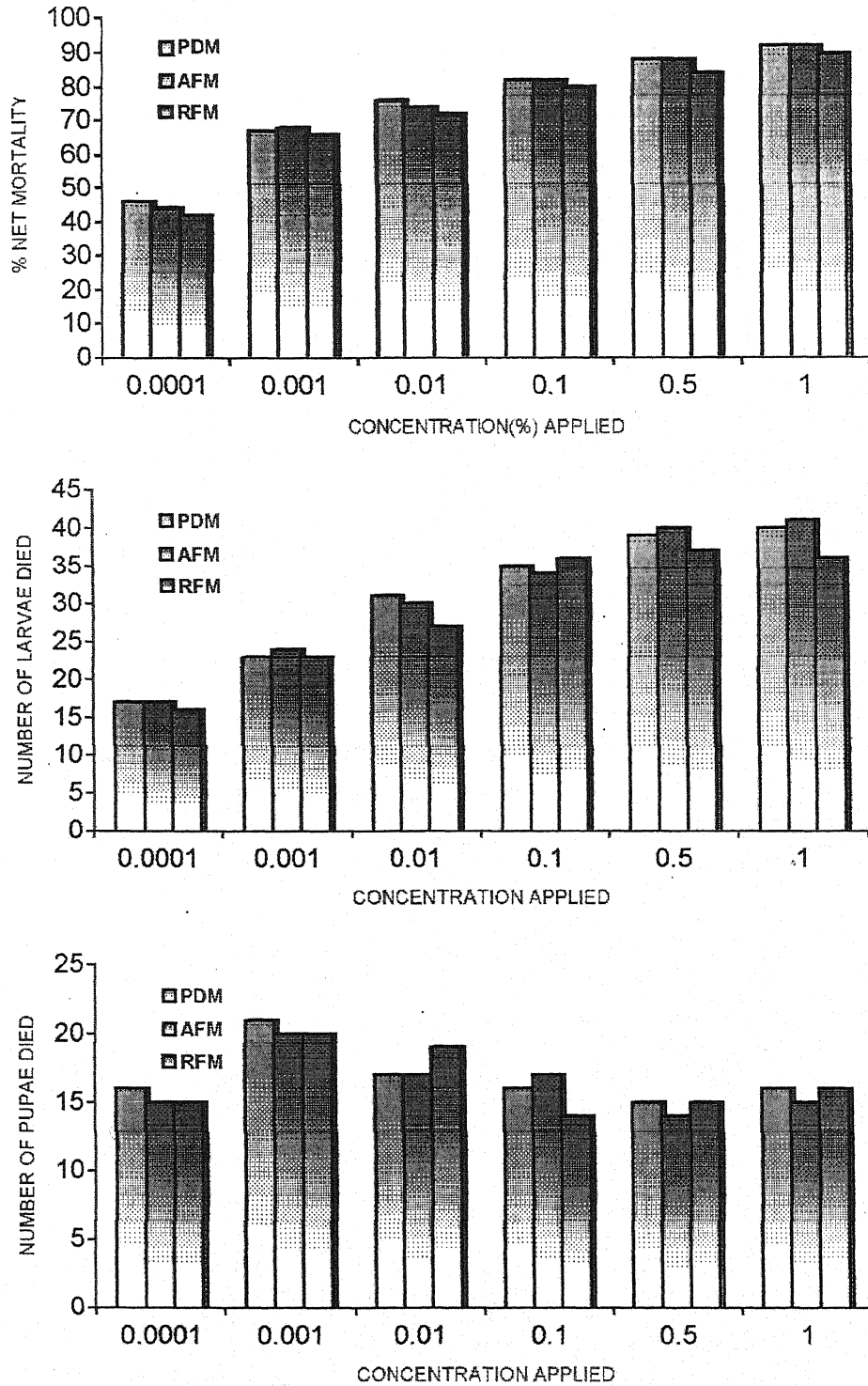
TABLE No. 19 : Net mortality in _Pericillia ricini_ Fab. caused by Diamino-furyl-s-triazine at different concentrations under different modes of treatment.
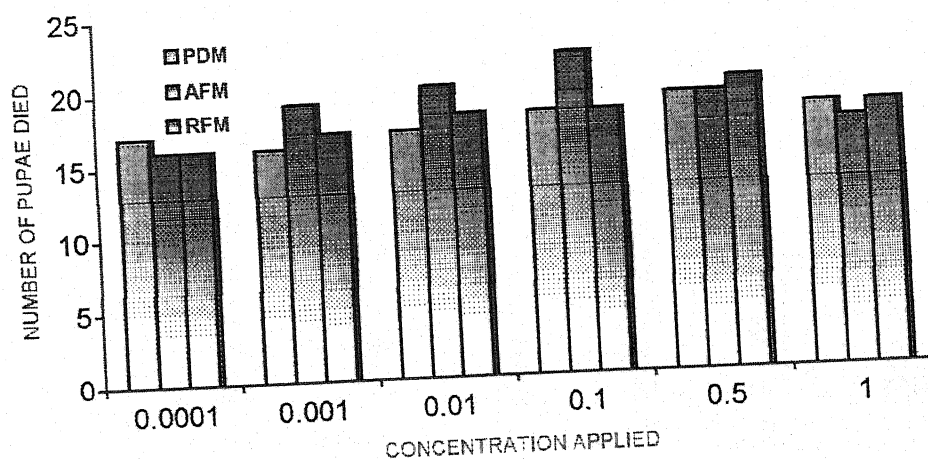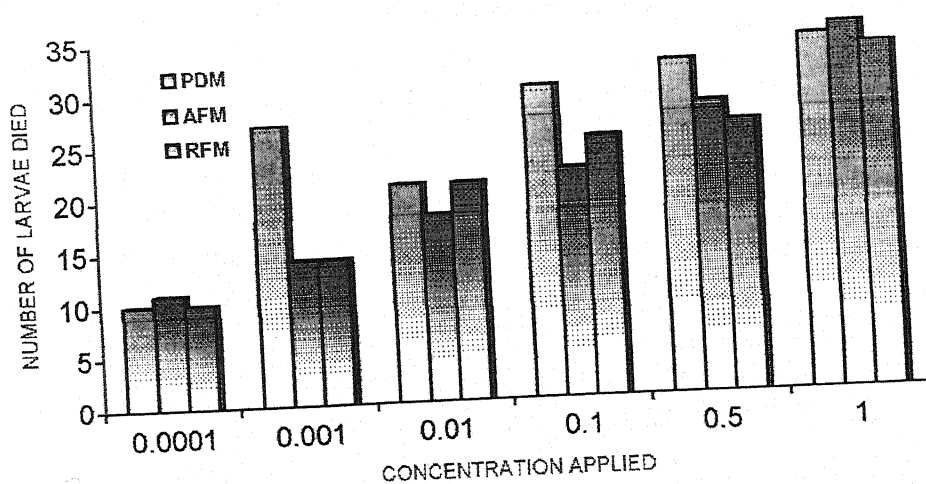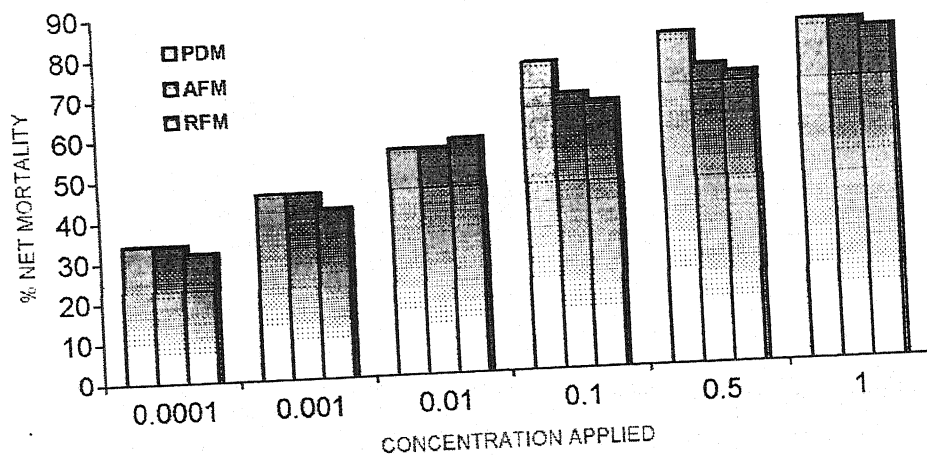
TABLE No. 20 : Net mortality in _Pericallia ricini_ Fab. caused by Benzoy Phenyl Urea at different concentrations under different modes of treatment.
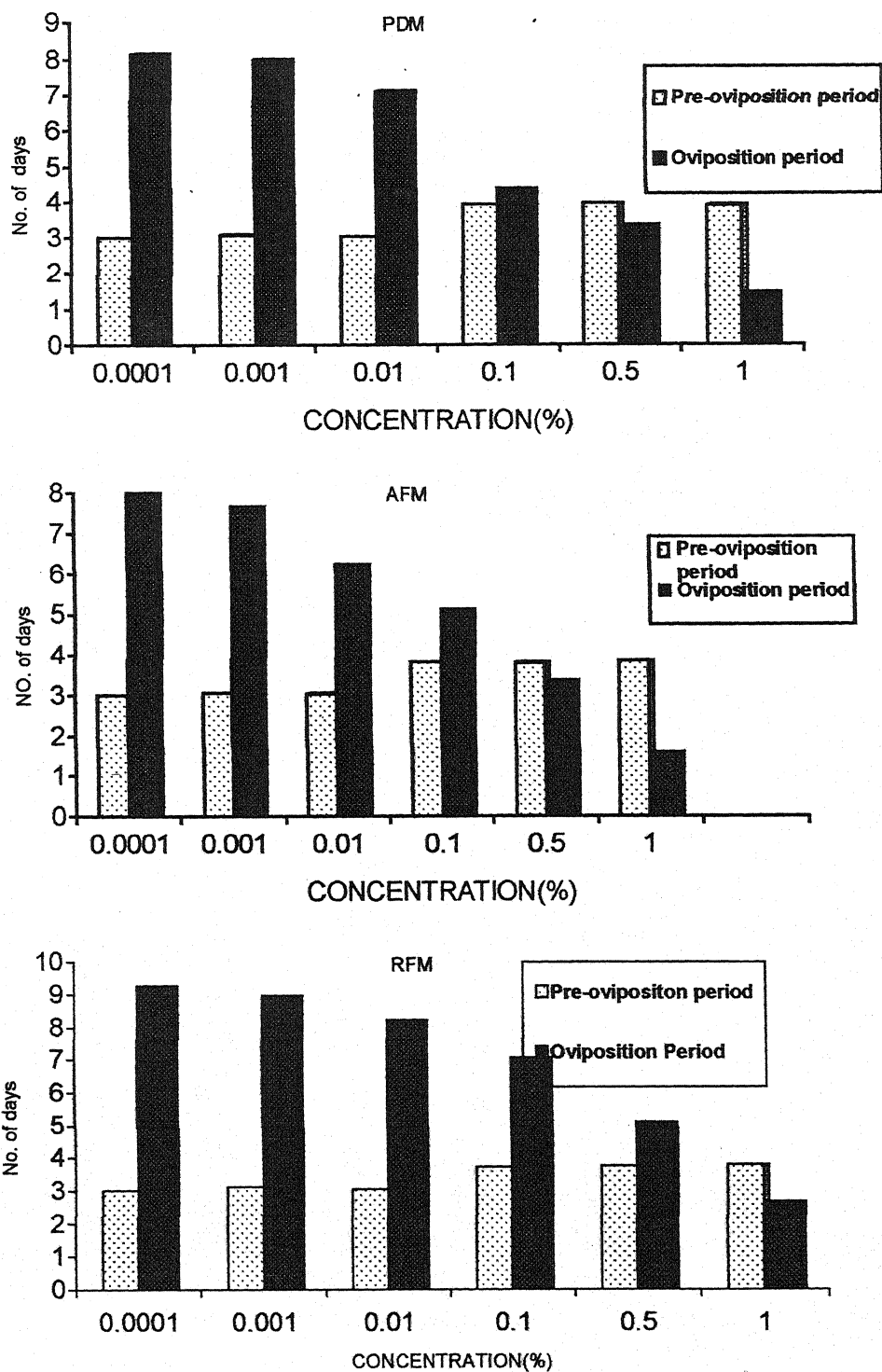
Fig. 21. Effect of Diflubenzuron on reproductive periods in _Pericallia ricini_ Fab.
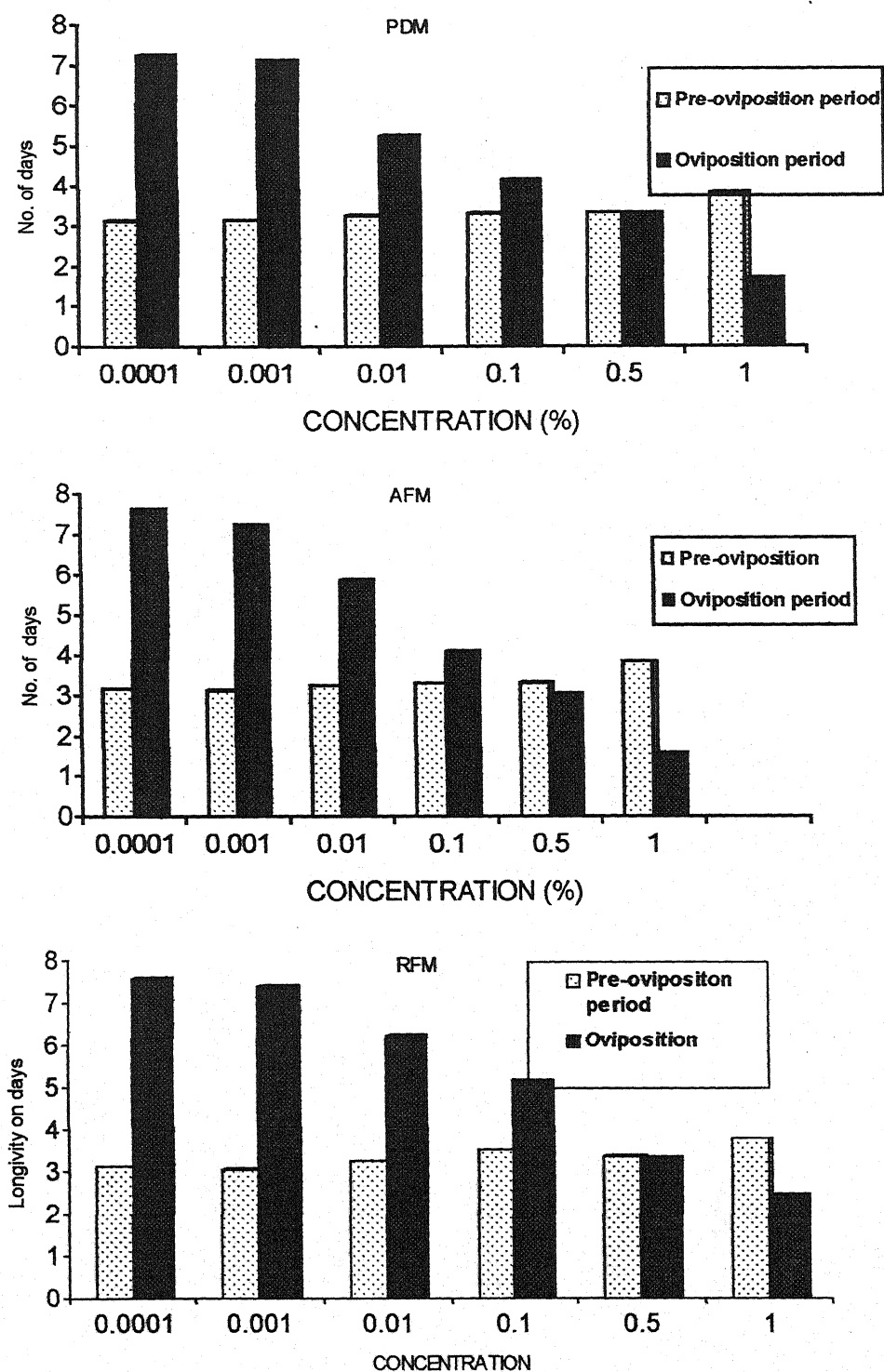
Fig. 22. Effect of Penfluron on reproductive periods in Pericallia ricini Fab.
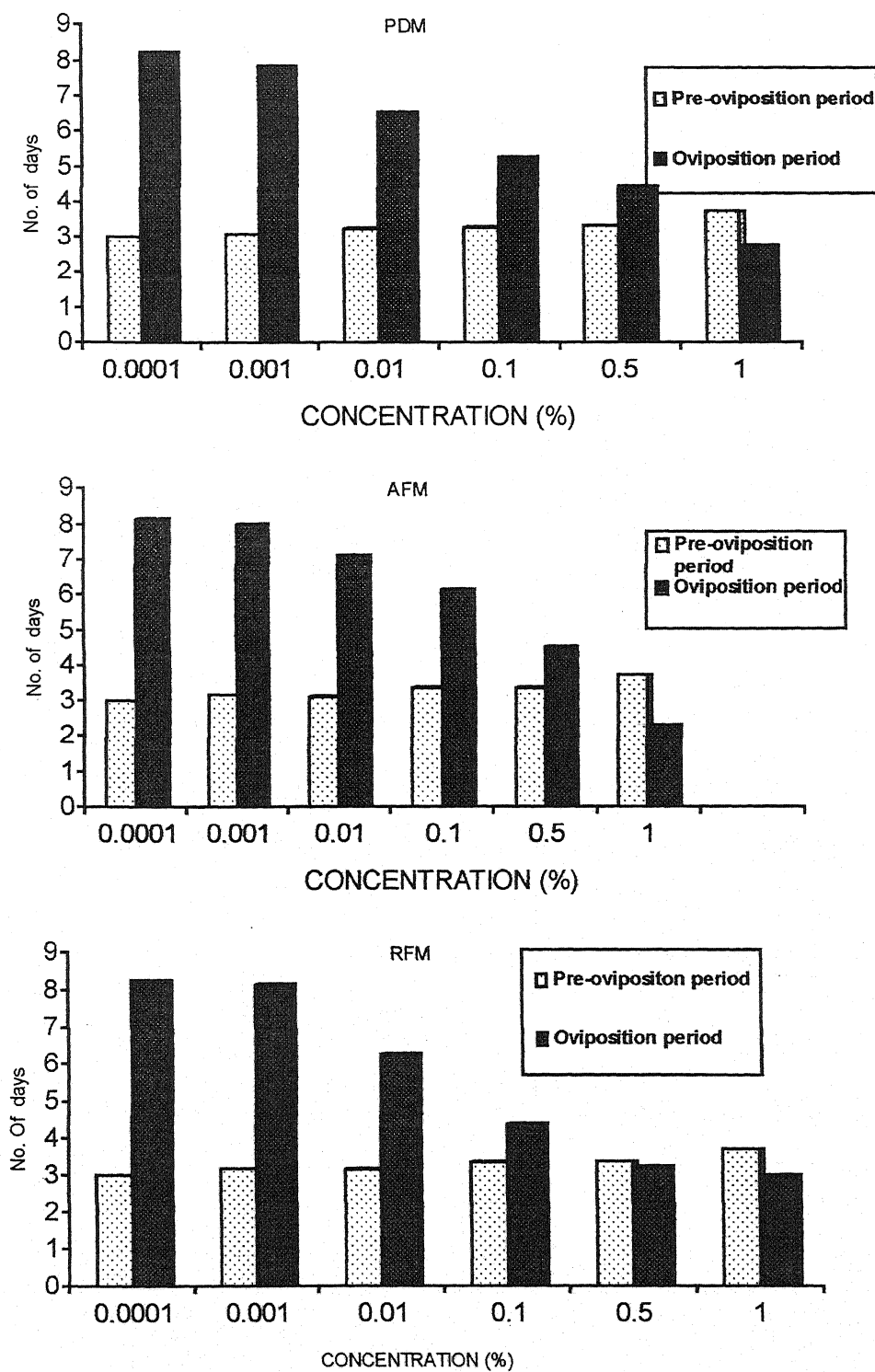
Fig ble 23. Effect of Diaminofuryl-s-triazine on reproductive periods in Pericallia ricini Fab.
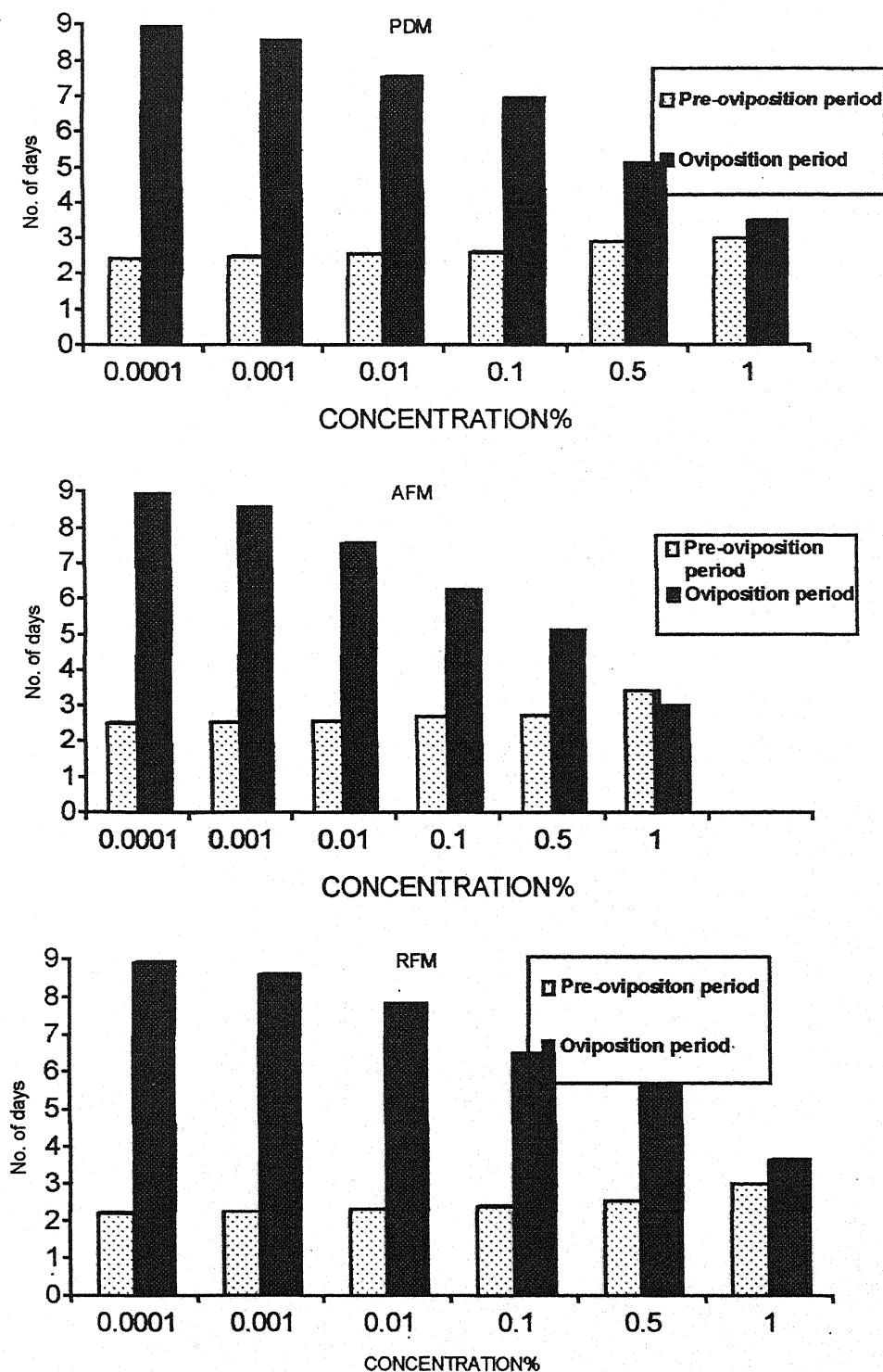
Fig. 24. Effect of Benzoyl Phenyl Urea on reproductive periods in _Pericallia ricini_ Fab.
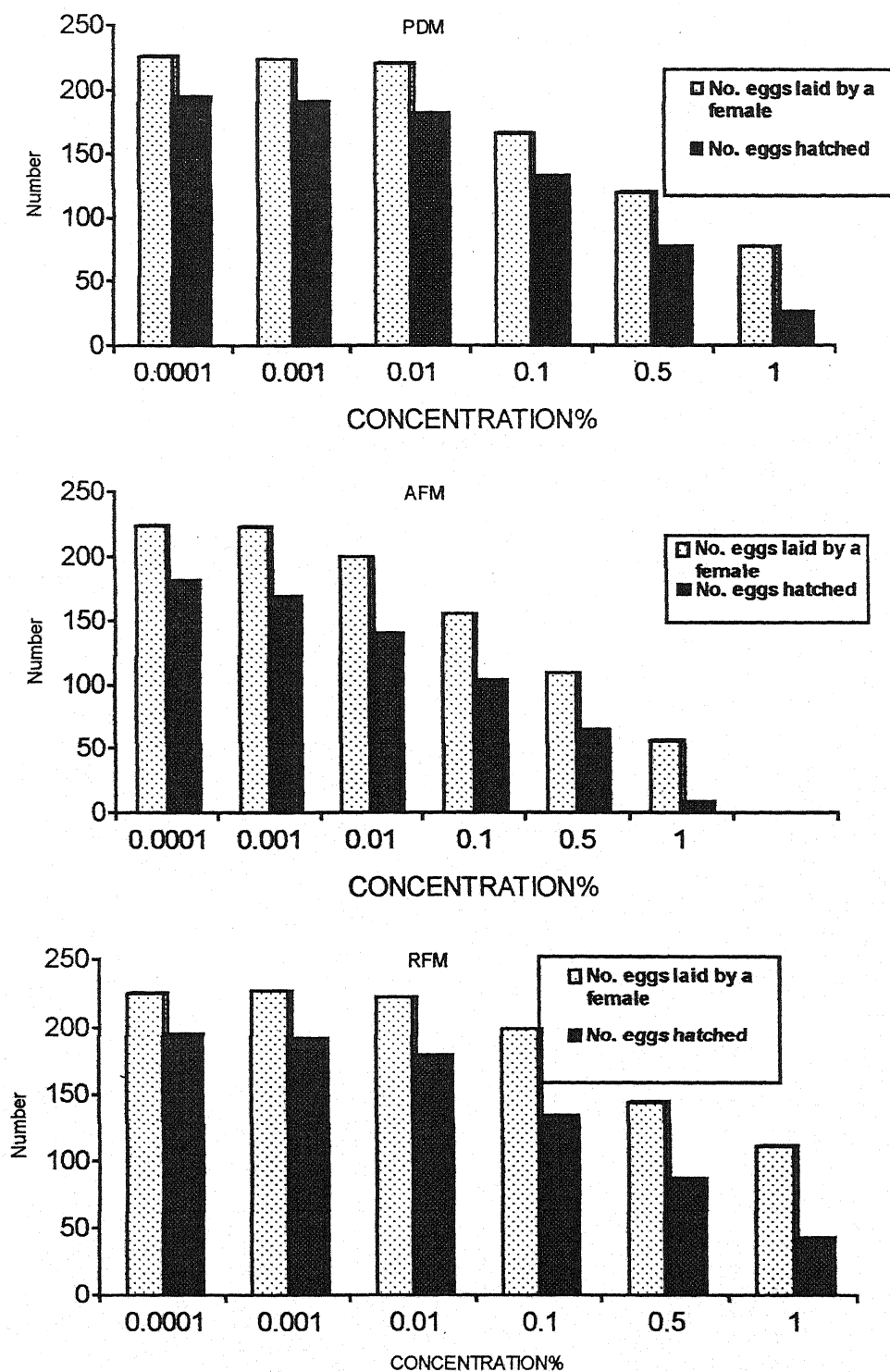
Fig. 25. Effect of Diflubenzuron on fecundity and fertility in <u>Pericallia ricini</u> Fab
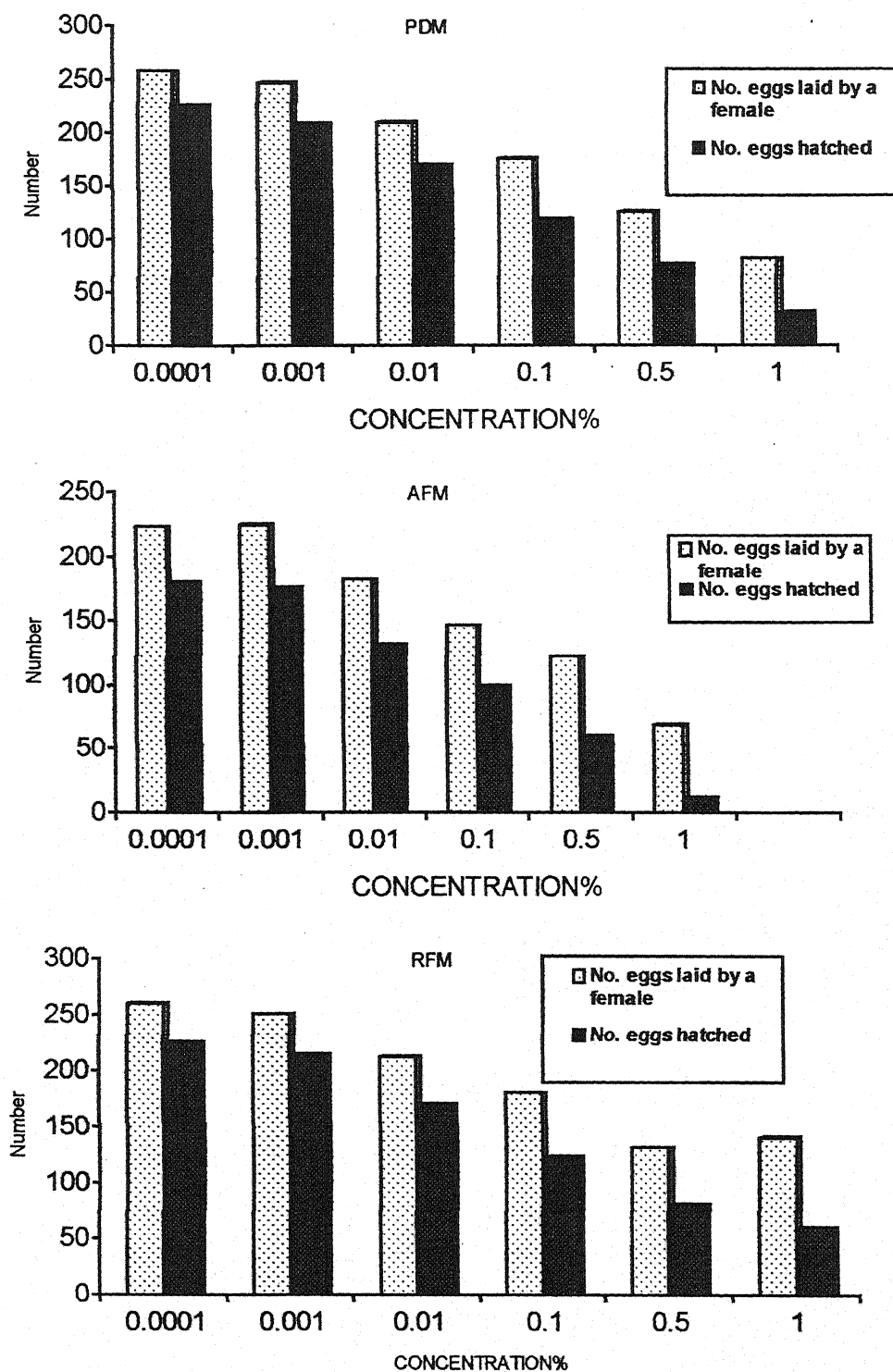
Fig. 26 Effect of Penfluron on fecundity and fertility in Pericallia ricini Fab.
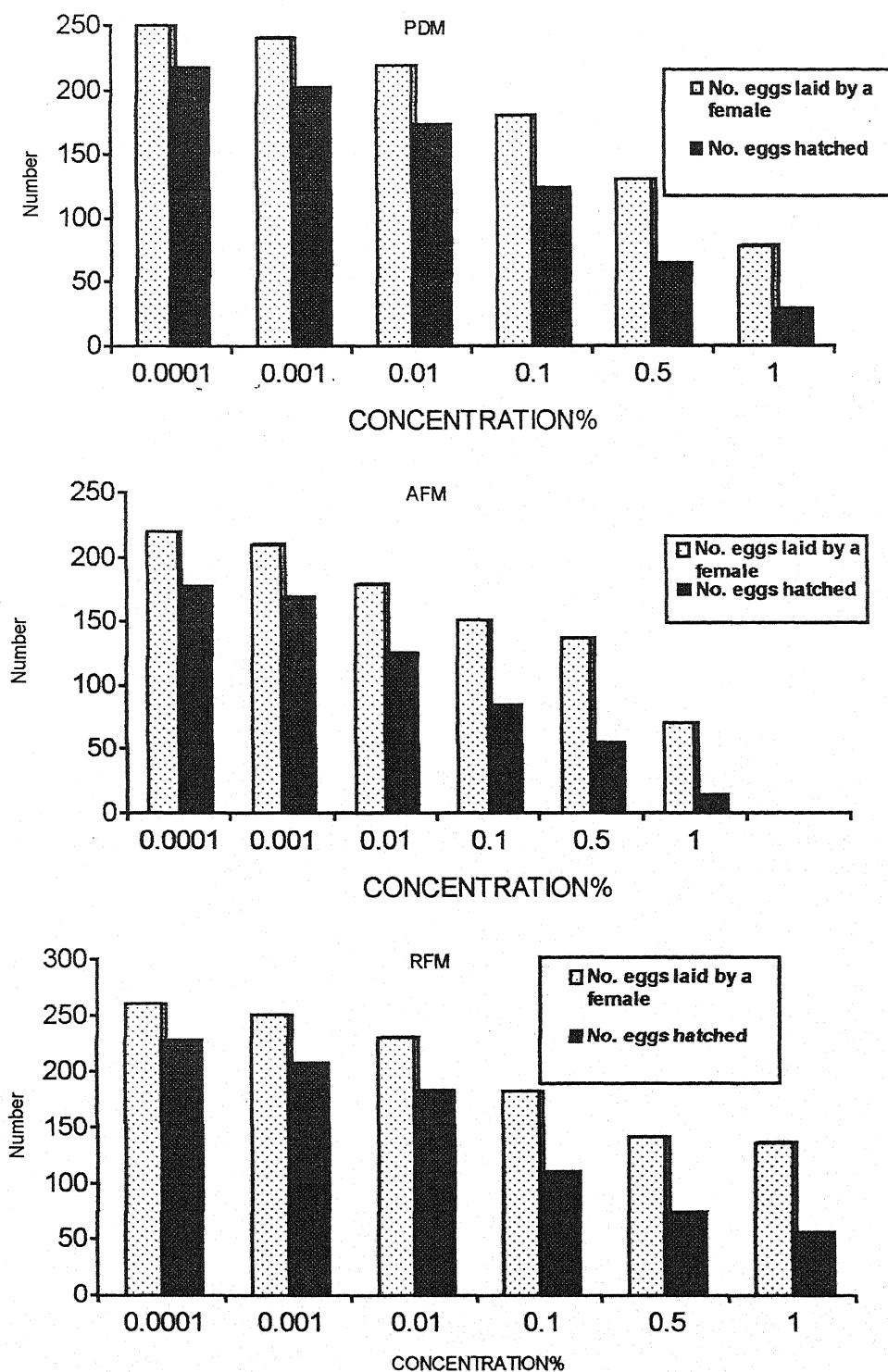
Fig. 27. Effect of Diamino furyl-s-triazine on fecundity and fertility in <u>Pericallia ricini</u> Fab.
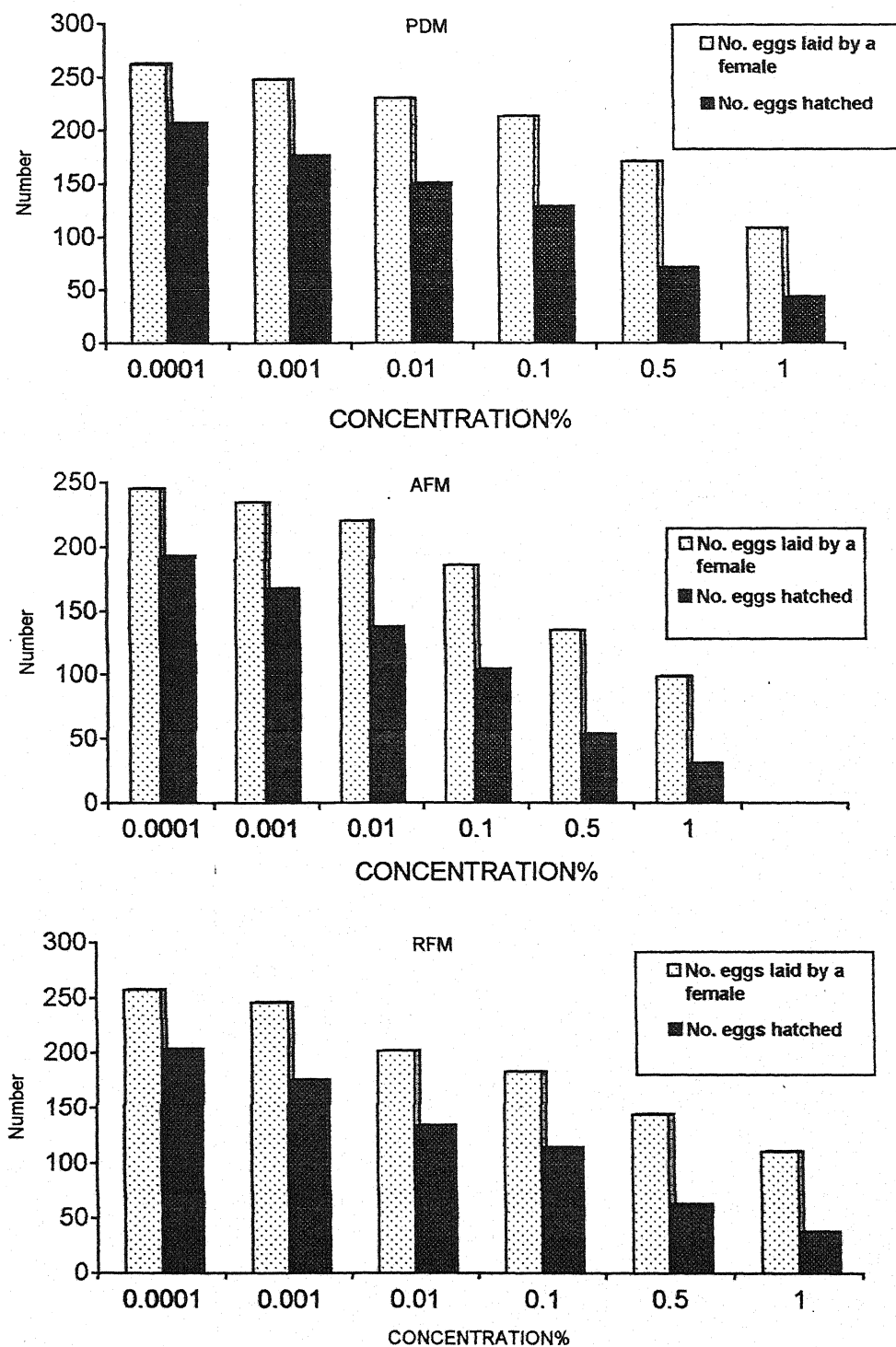
Fig. 28. Effect of Benzoyl Phenyl Urea on fecundity and fertility in Pericallia ricini Fab.
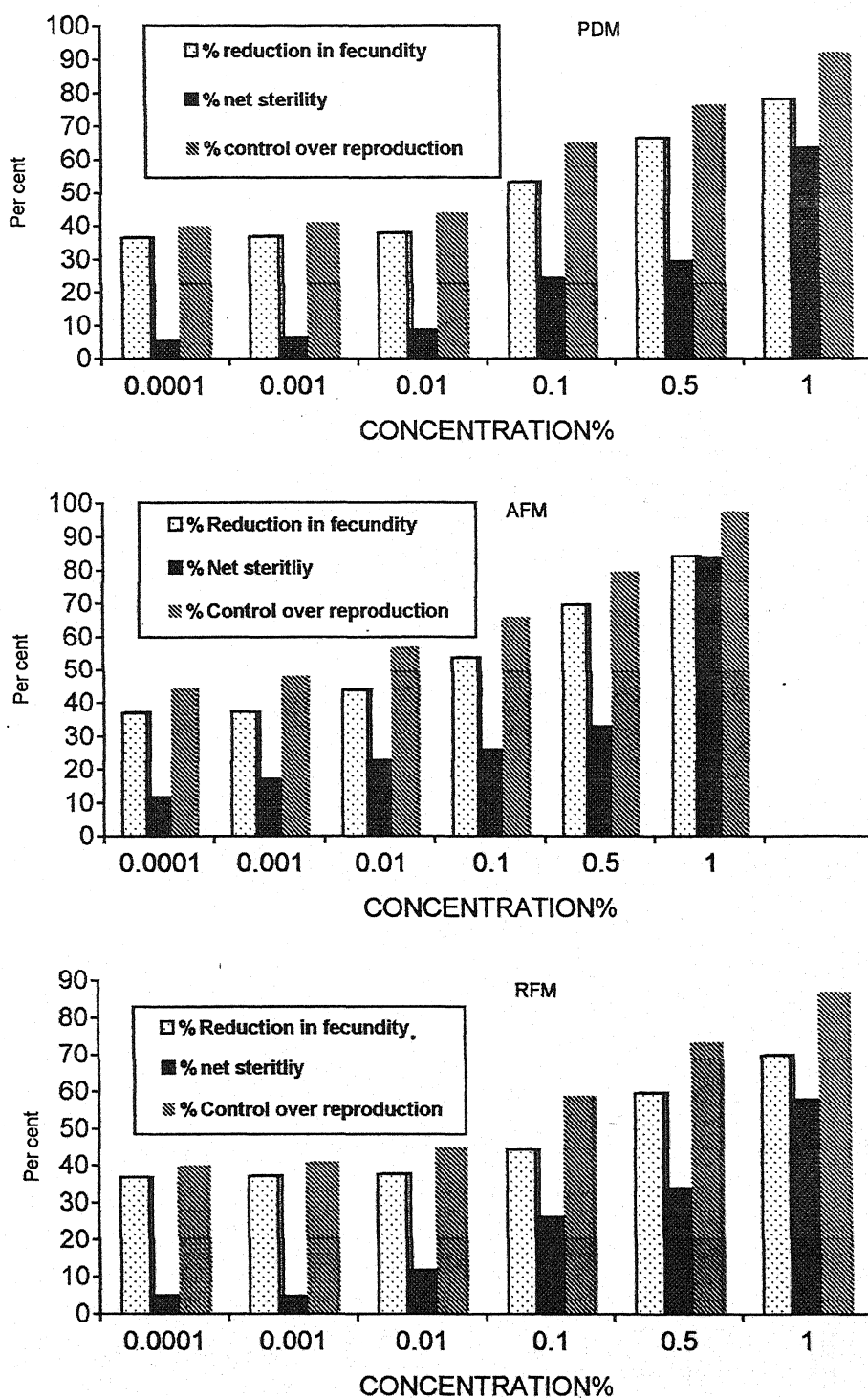
Fig.29. Per cent reduction in fecundity, per cent net sterility and per cent control over reproduction in <u>Pericallia</u> <u>ricini</u> Fab. caused by Diflubenzuron under different modes of treatment.
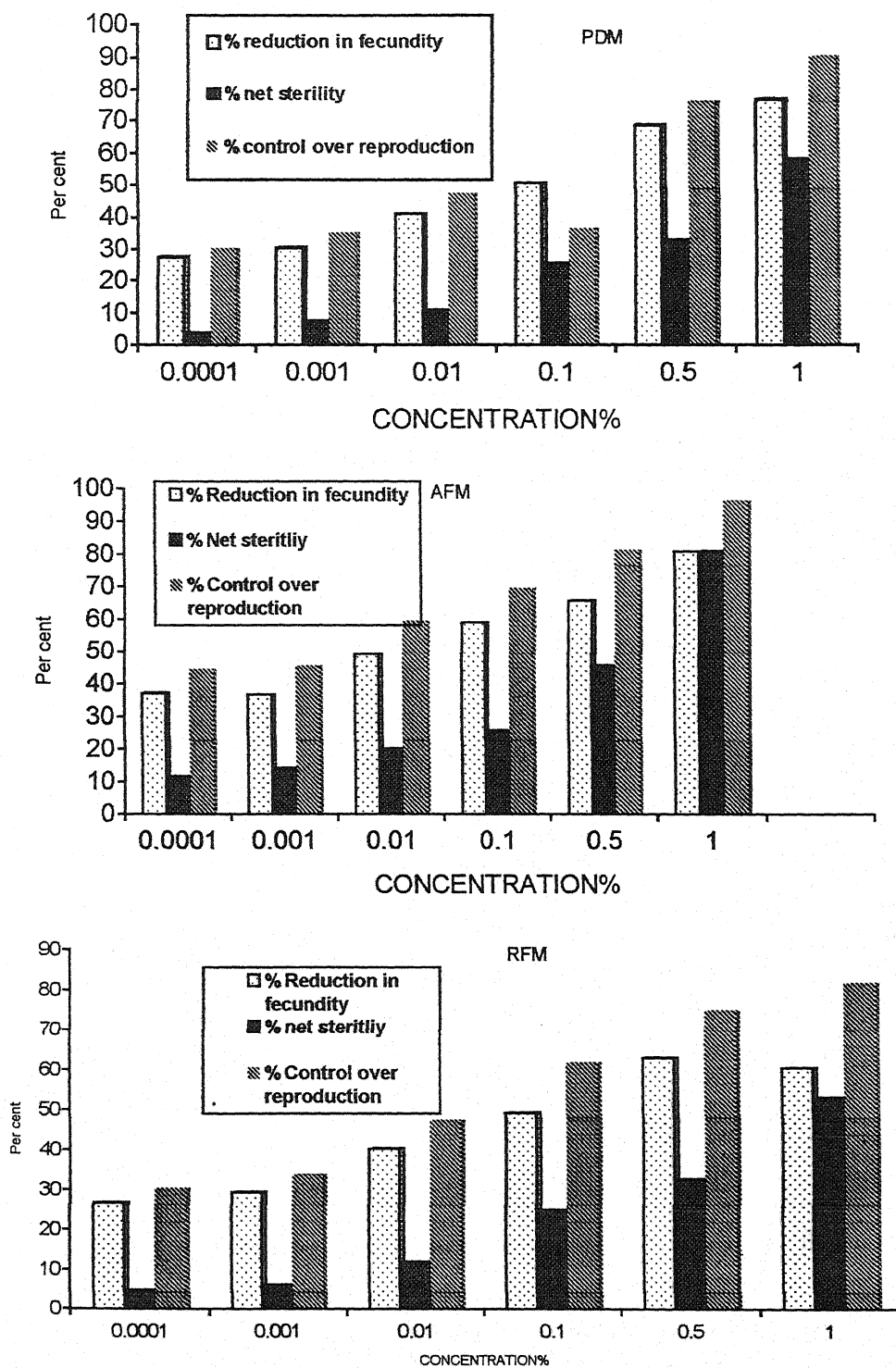
Fig. 30. Per cent reduction in fecundity, per cent net sterility and per cent control over reproduction in <u>Pericallia</u> <u>ricini</u> Fab. caused by Penfluron under different modes of treatment
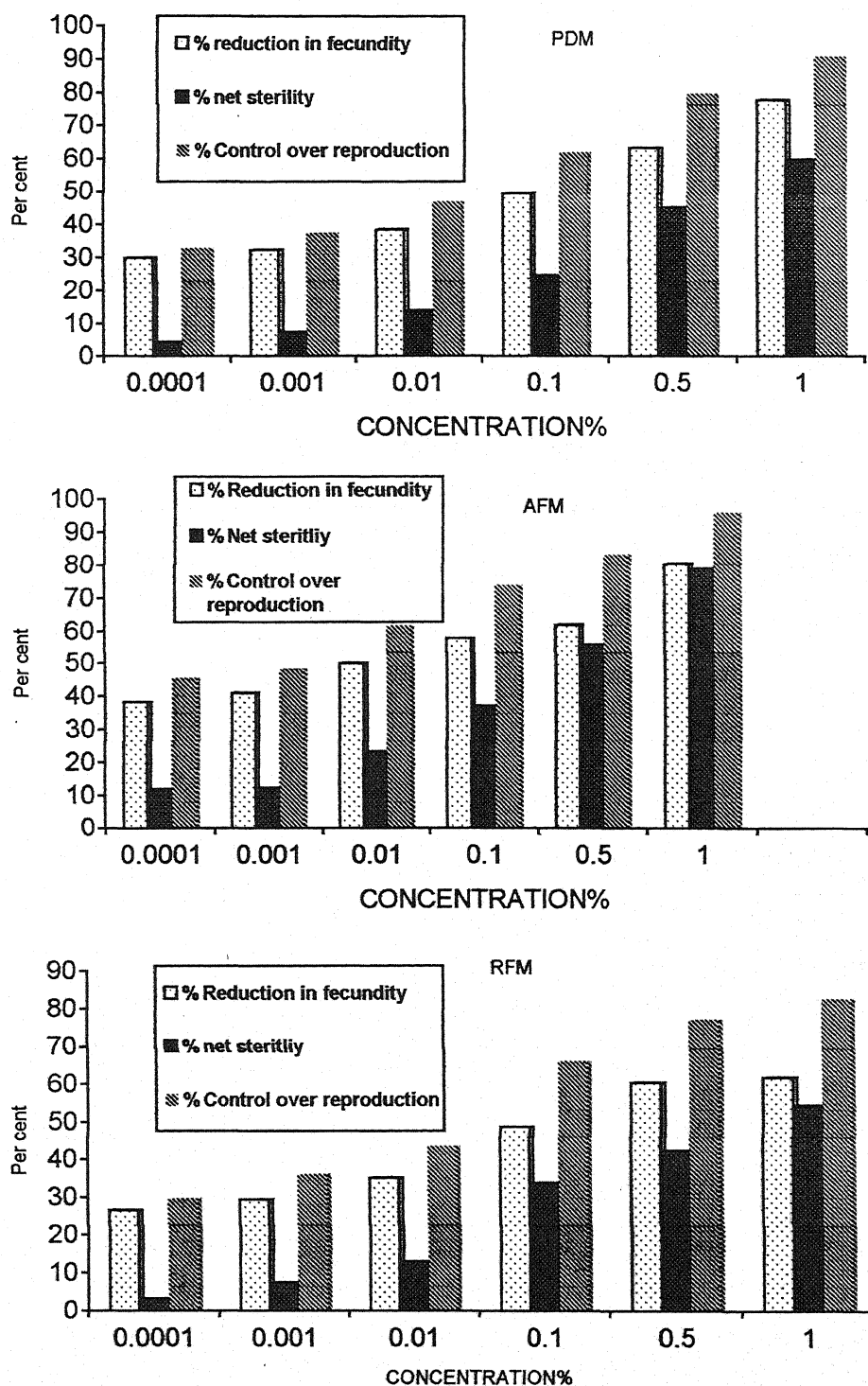
Fig. 31. Per cent reduction in fecundity, per cent net sterility and per cent control over reproduction in _Pericallia ricini_ Fab. caused by Diamino-furyl-s-triazine under different modes of treatment
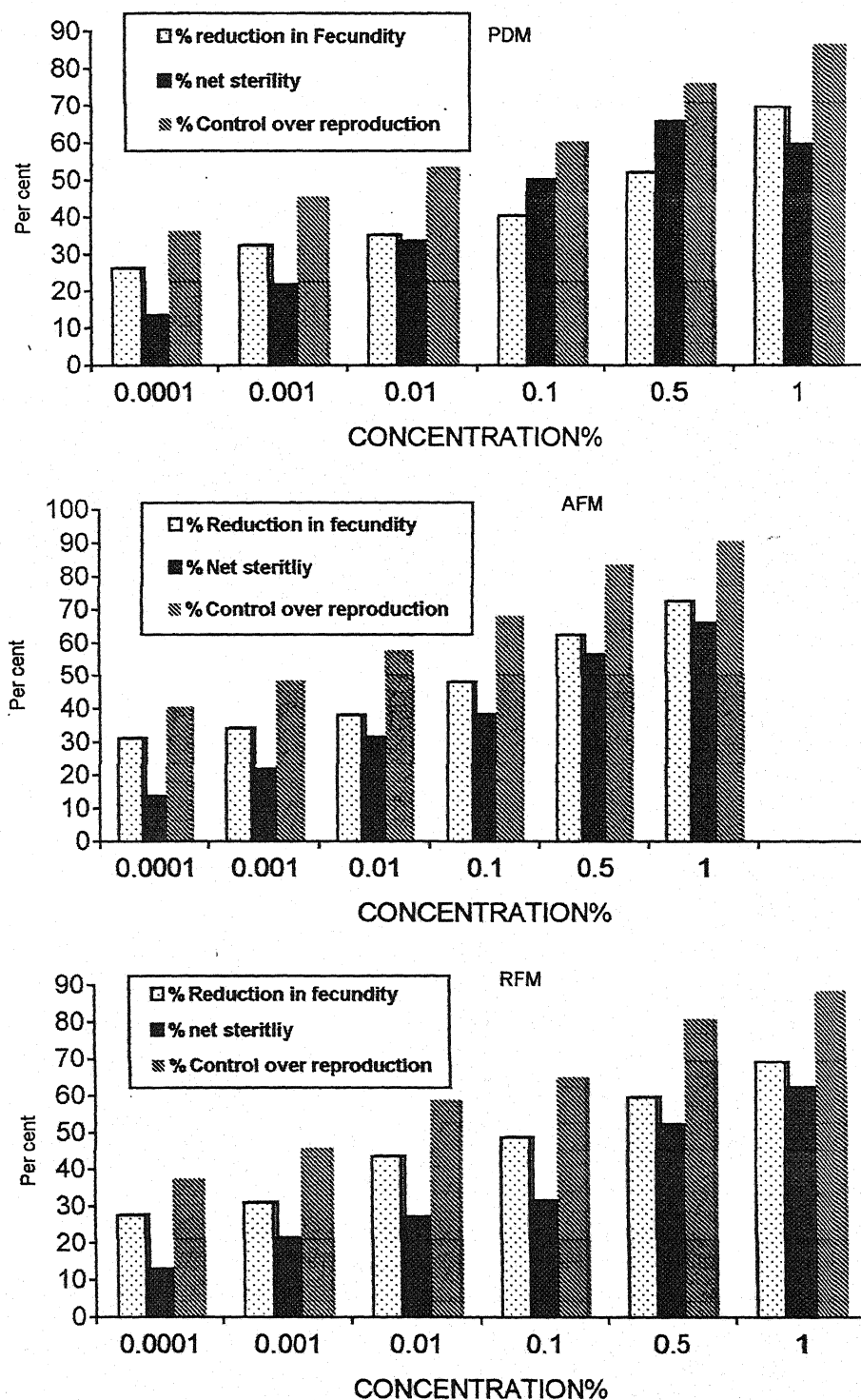
Fig. 32. Per cent reduction in fecundity, per cent net sterility and per cent control over reproduction in Pericallia ricini Fab. caused by Benzoyl Phenyl Urea under different modes of treatment.
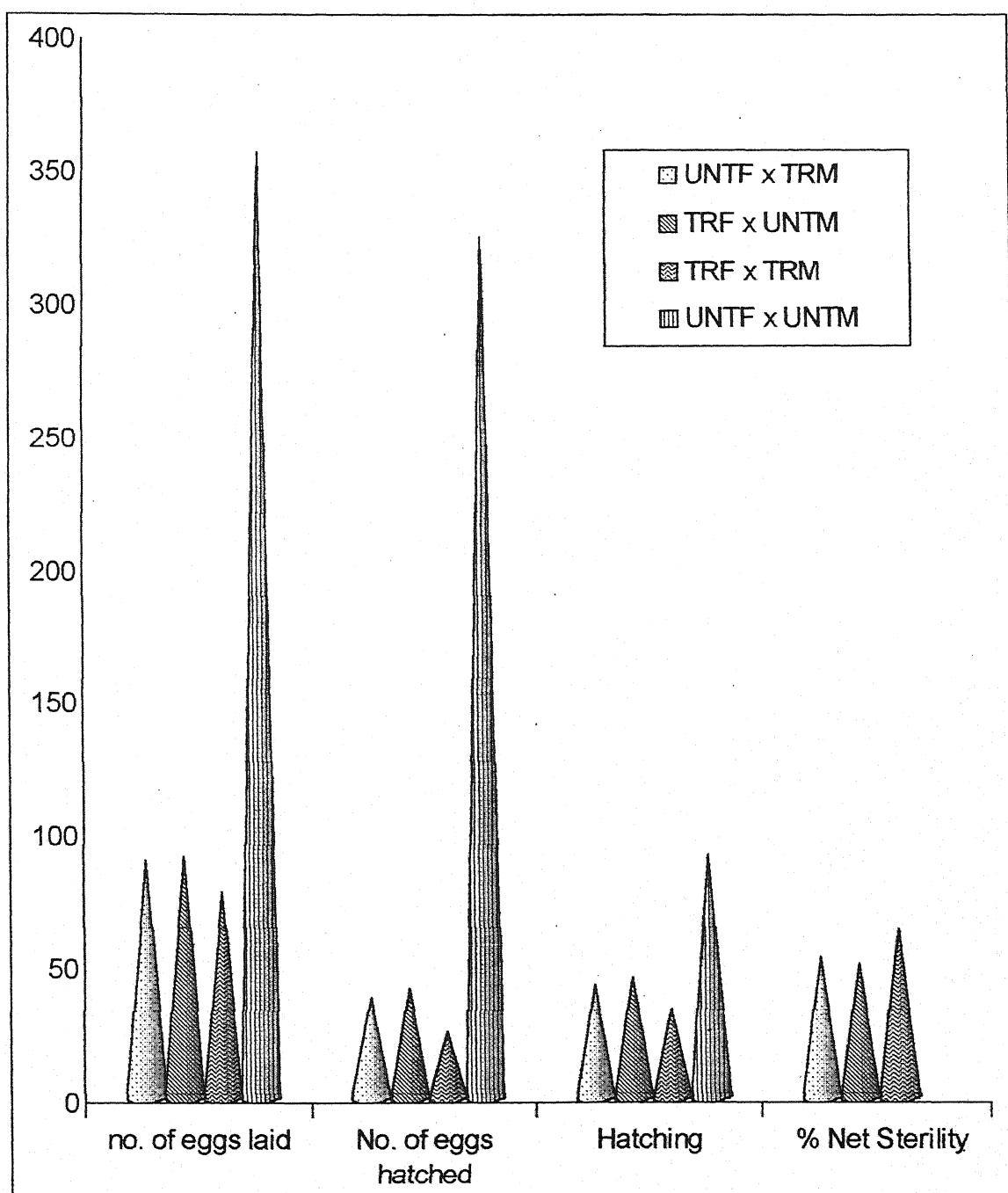
Graph 33 : Sex specific effect of Diflubenzuron on reproduction in Pericallia ricini Fab. (1 per cent Diflubenzuron applied by PDM for 1 minute only)
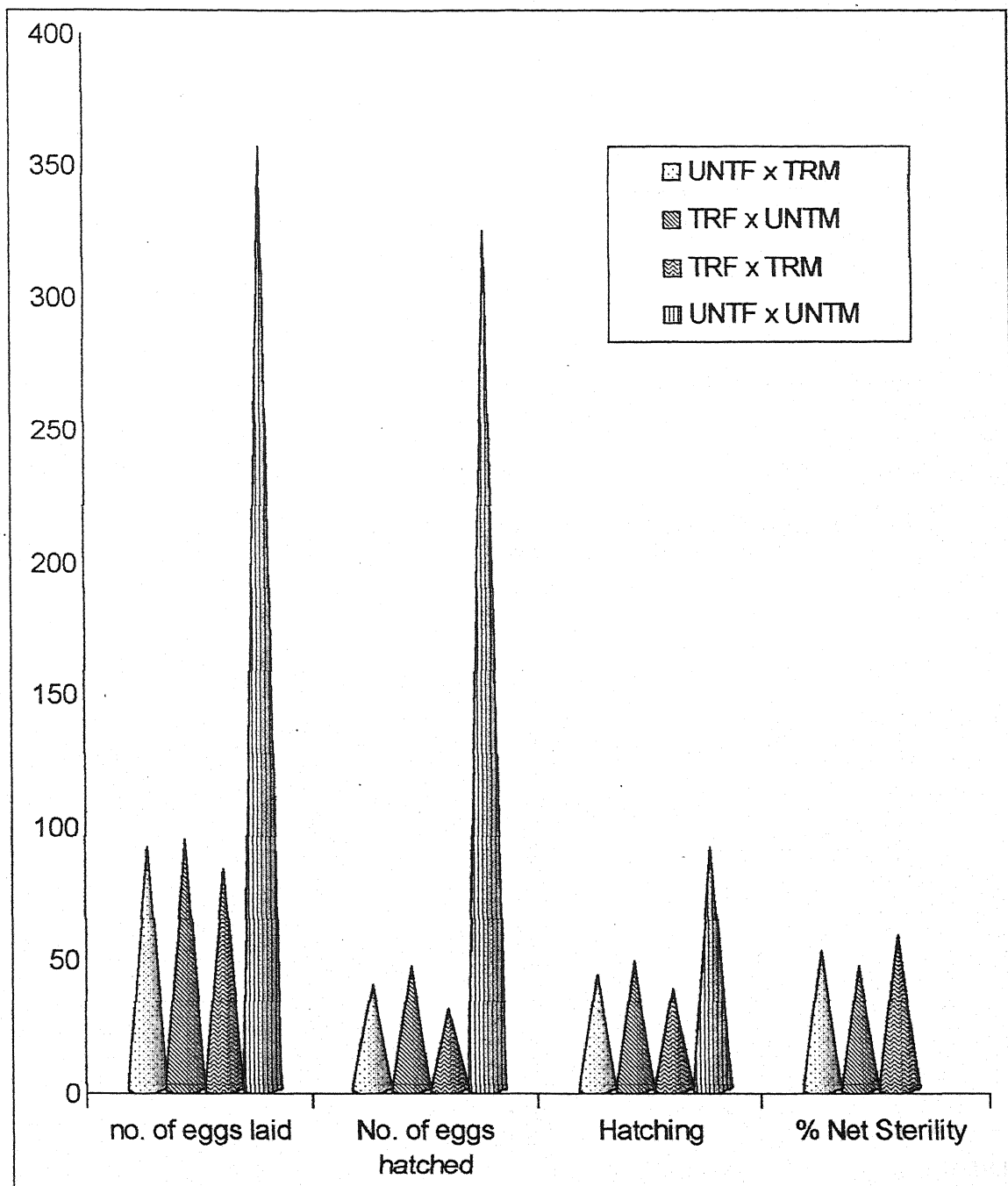
Graph 34 : Sex specific effect of Penfluron on reproduction in Pericallia ricini Fab. (1 per cent Penfluron applied by PDM for 1 minute only)
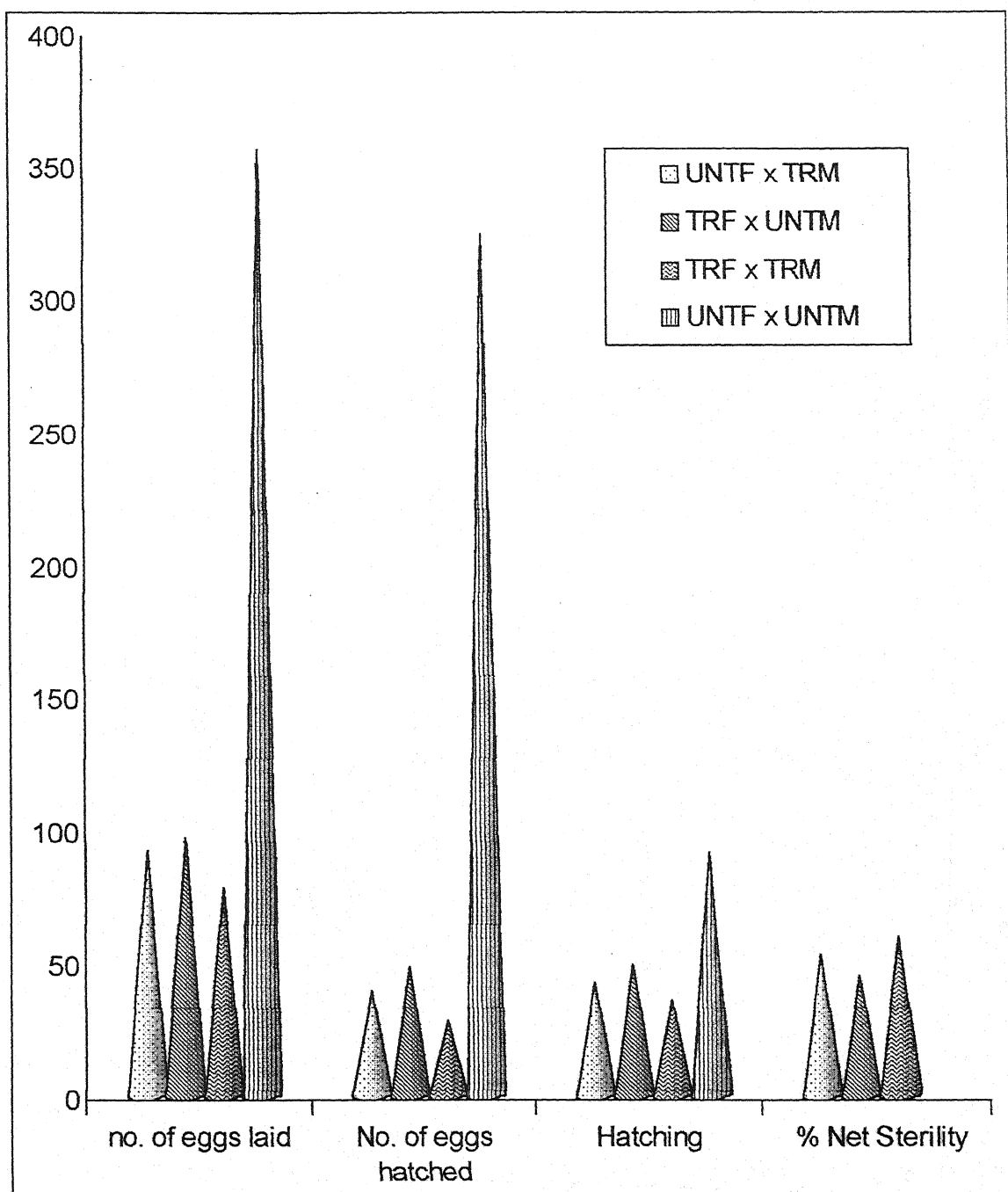
Graph 35 : Sex specific effect of Diamino-furyl-s-triazine on reproduction in Pericallia ricini Fab. (1 per cent Diamino-furyl-s-triazine applied by PDM for 1 minute only)
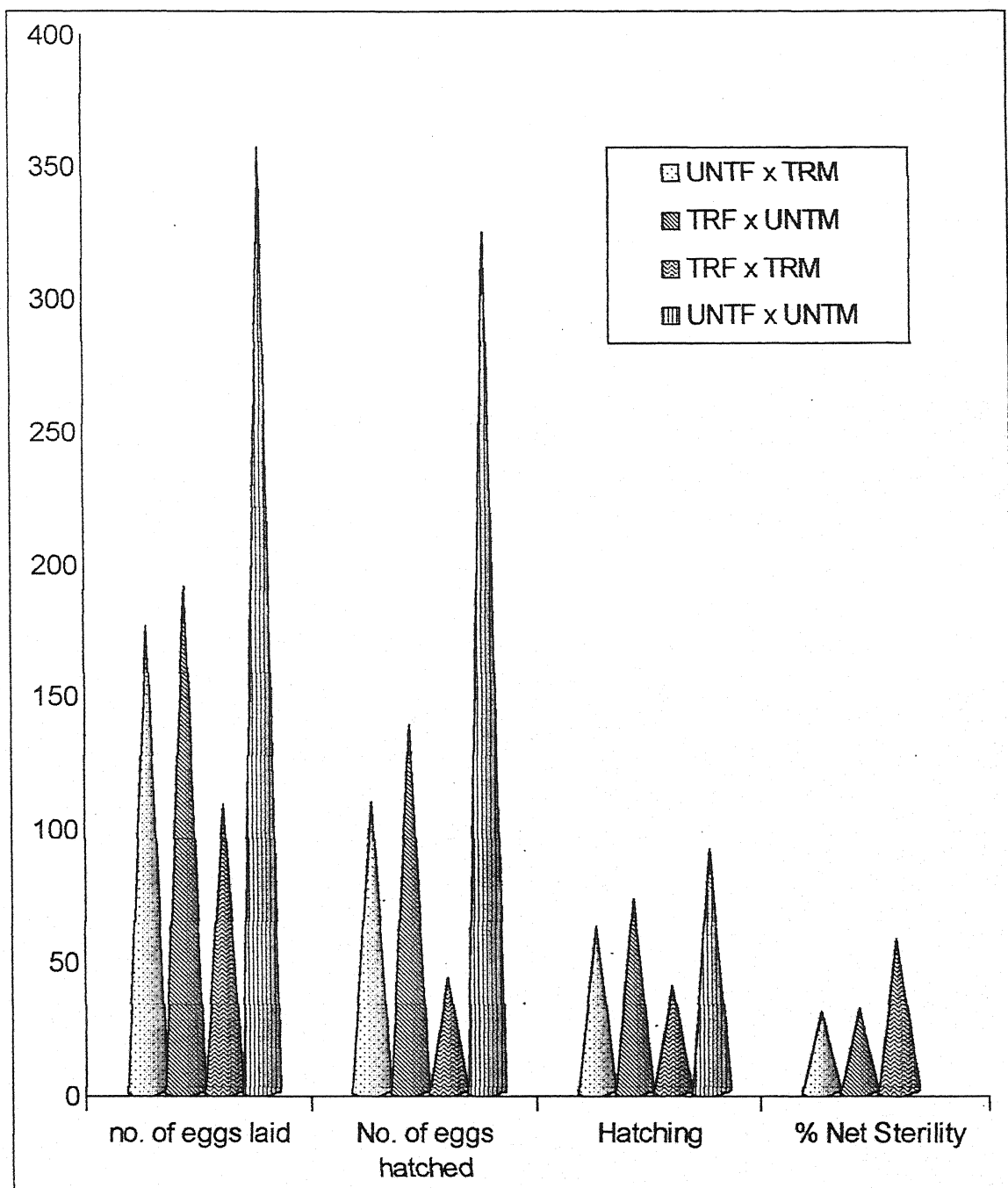
Graph 36 : Sex specific effect of Benzoyl Phenyl Urea on reproduction in <u>Pericallia</u> <u>ricini</u> Fab. (1 per cent Benzoyl Phenyl Urea by PDM for 1 minute only).

Chapter - V

Results

RESULTS

5.1 EFFECTS OF INSECT GROWTH REGULATORS ON GROWTH

Results have been presented in Tables I to 8 and Figs. 1 to 8.

5.1A Effects of diflubenzuron on growth :

      Data pertaining to influence of diflubenzuron on growth has been given in Table 1 and 5 and Figs. 1 and 5.

5.1A I Effects of diflubenzuron on biomass accumulation in larva:

      Data have been presented in Table 1 to 8.

5.1A Ia Effects of diflubenzuron on biomass accumulation in larva under P.D.M. (Table 1 and fig. 1) :

      Larva of the control experiment accumulated 4.30 mg biomass on the 5th day of list life. Whereas the larval biomass on the same day varied from 1.67 to 3.80 mg under influence of different concentrations of diflubenzuron. The control larva acquired significantly more biomass than that of the larva under influence of any strength of the diflubenzuron used ($p < 0.01$). The larva under the effect of 0.0001% diflubenzuron had more weight (3.80 mg) than that obtained under the influence of 0.001% concentration of diflubenzuron (2.71 mg : P<

0.05). Further analysis of variance revealed that 0.01, 0.10 and 0.50% concentrations has almost similar effect on the biomass accumulation (2.42 to 2.74 mg) on the 5th day of the larval period. But at any of these concentration the larva had more biomass than that of the larva under the influence of either 0.50% or 1.00% had (1.75 mg, 1.67 mg) concentration (P< 0.05). Further 0.50 and 1.00% had almost identical effect of the biomass accumulation (P> 0.05). Thus, on the basis of the biomass accumulation in the larva on the 5th day, the tested concentration of the diflubenzuron could be arranged as 0.0001% > 0.001, 0.01 & 0.10 > 0.50 and 1.00%.

On the 10th day of its life, the control larva had 22.64 mg biomass which was significantly more than that of the larva on the same day under the influence of any strength of diflubenzuron from 0.0001 to 1.00% (P< 0.01). In response to treatment of different concentrations of diflubenzuron earlier at the pupal stage, varied from 6.80 to 15.71 mg and the analysis of variance test revealed that the biomass of the larva on this day differed significantly with the strength of the diflubenzuron (P< 0.05). The biomass of the larva exhibited the tendency of decrease with increase in concentration of the diflubenzuron on the 10th day of the larval period.

The biomass of the control larva was 110.93 mg on the 15th day and it was significantly more than that of the larva on the same day under influence of any concentration of the diflubenzuron used (P< 0.01). In response to treatment with different concentration of diflubenzuron earlier at the pupal stage,

the biomass of the larva on the 15th day from 20.64 to 70.62 mg and it differed significantly with the strength of the diflubenzuron (P< 0.01). The biomass decreased with increase in the concentration of the insect growth regulator.

5.1A. Ib Effects of diflubenzuron on biomass accumulation in larva under A.F.M. (Table-1 and fig.-1):

On the 5th day larva not subjected to treatment of diflubenzuron acquired 4.30 mg weight and this accumulated biomass was distinctly more than the biomass accumulated by the larva subjected earlier to treatment of any strength of diflubenzuron under A.F.M. (P< 0.05). The biomass of the larva varied from 1.78 to 3.82 mg in response to treatment of different strengths of diflubenzuron under this method and it appeared to decrease with increasing concentration of the insect growth regulator. At 0.0001% concentration of the diflubenzuron, larva had more weight (3.82 mg) than that acquired by it (1.78 to 2.94 mg) at any of the other concentrations of this insect growth regulator (P< 0.01). Weight of larva at 0.001, 0.01 and 0.10 concentration (2.46 to 2.94 mg) were not different statistically (P> 0.05) but biomass of larva at any of these concentrations was certainly more than that acquired at 0.50% concentration of the diflubenzuron (P< 0.05). Further, the weight of the larva at 1.00% (1.76 mg) appeared to be lesser than that at the 0.50% concentration of the diflubenzuron but the difference between these two weight was not found to be significant (P> 0.05).

On the 10th day of its life, the control larva accumulated 22.64 mg biomass which was significantly more than that accumulated by the larva in response to treatment earlier at the pupal stage with any of the concentrations of the diflubenzuron used (P< 0.01). As regards the effect of different concentrations of diflubenzuron on the biomass accumulation in the larva on the 10th day, it varied from 6.94 to 15.76 mg among them and Anova revealed that the biomass differed with the concentration of the diflubenzuron (P< 0.05) and it decreased with the increasing concentrations of the insect growth regulator.

On the 15th day of the larval period, control larva obtained far more weight (110.93 mg) than that of the larva treated earlier at pupal stage with any concentration of the diflubenzuron from 0.0001% to 1.00% (P< 0.01). The biomass of the larva varied form 22.57 to 71.06 mg among different concentrations of the diflubenzuron and the statistical analysis revealed that it differed form concentration to concentration (P< 0.01). Further, the biomass of the larva showed a tendency of decrease with increase in the concentration of the diflubenzuron.

5.1A. Ic. Effects of diflubenzuron on biomass accumulation in larva under R.F.M. (Table-1 and fig.-1) :

Larva of untreated adult acquired significantly more weight (4.30 mg) on the 5th day in comparision to larva of treated adult with any concentration of diflubenzuron (P< 0.05). Further, the biomass of the larva treated earlier at adult stage with 0.0001% concentration of the diflubenzuron (3.82 mg) was more

than that of the larva treated earlier at adult stage either with 0.001% (2.95 mg), or 0.01 (2.76 mg) or 0.10 (2.43 mg) concentration of the diflubenzuron ($P < 0.05$) but the weight acquired by the larva at any of the latter three concentrations was almost indentical (2.43 to 2.95 mg; $P < 0.05$). However, the weight (2.0 mg) acquired by the larva was considerably lesser at 0.50% concentration than that acquired at lower concentraions ($P < 0.05$) but it was identical to that (1.80 mg) acquired at 1% concentration of diflubenzuron.

On the 10th day also, the larva of the adult not treated with the diflubenzuron acquired more weight (22.64 mg) than that which was treated earlier at adult stage with any of the concentrations used ($P < 0.05$). In response to treatment with different concentrations from 0.0001 to 1%, the larval biomass varied from 6.84 to 15.77 mg and it differed with the concentration ($P < 0.05$) and decreased with increasing concentration.

The control larva on the 15th day accumulated 110.93 mg biomass, whereas it obtained 23.88 to 72.46 mg in response to treatment earlier at adult stage with different concentrations of diflubenzuron from 0.0001 to 1% and it differed with the concentration ($P < 0.01$), tending to decrease with increasing concentration.

Corresponding concentrations under all methods of treatment exerted similar influence on the larval biomass on the 5th and 10th day. Quite like this on the 15th day also each strength of diflubenzuron under R.F.M. exerted

influence on the larval biomass which was identical to that at corresponding concentration either under A.F.M. or R.F.M. (Fig. 1).

5.1A. II. Effects of diflubenzuron on biomass acquisition in pupae and adults:

Data pertaining to this aspect have been presented in Table 5-8 and Fig. 5-8.

5.1A. IIa . Effects of diflubenzuron on biomass acquisition in pupae and adults under PDM (Table 5 and figs. 5) :

Untreated pupa resulted in heavier pupa (152.60 mg) than the treated pupa with any concentration of the diflubenzuron under P.D.M. ($P< 0.01$). Weight of the pupa varied from 69.56 to 140 mg in response to different concentrations of the insect growth regulator under this method of treatment and it was detected to differ with the concentration ($P< 0.01$) and decreased with the increasing concentration (Table-5).

Like the pupa obtained from the untreated pupa, the male obtained from the untreated pupa was heavier (106.47 mg) than that obtained from the pupa treated with any concentration of the diflubenzuron. Weight of the male varied from 48.36 to 95.36 mg in response to the pupal treatment with different concentrations of the diflubenzuron and as per analysis of variance, the weight of the male depended on the concentration of the insect growth regulator ($P< 0.01$) with a clear tendency of decrease with increasing concentration (Table -5).

Like the pupa obtained from the untreated pupa, the male obtained from the untreated pupa was heavier (106.47 mg) than that obtained from the pupa treated with any concentration of the diflubenzuron. Weight of the male varied from 48.36 to 95.36 mg in response to the pupal treatment with different concentrations of the diflubenzuron and as per analysis of variance, the weight of the male depended on the concentration of the insect growth regulator ($P < 0.01$) with a clear tendency of decrease with increasing concentration (Table -5).

Female obtained form untreated pupae weighted more (112.06 mg) than that obtained from the pupae treated with any concentration of the diflubenzuron. Further, the weight of the female varied from 51.39 to 104.46 mg in response to pupal treatment with different concentrations of the diflubenzuron and the statistical analysis revealed that it was dependent on the concentration of the insect growth regulator ($P < .01$) and it decreased with increase in the concentration.

5.1A. IIb. Effects of diflubenzuron on biomass acquisition is pupae and adults under A.F.M. (Table –5) :

Pupa obtained from the male and female treated with any of the concentrations of the diflubenzuron was considerably lighter than that obtained from the untreated pair ($P < 0.001$). The biomass of the pupa in response to treatment with different concentrations of the diflubenzuron varied from 66.12 to 134.36 mg, decreasing with the increasing concentration and it was detected to depend on the concentration (Anova, $P < 0.01$).

The biomass of the male obtained from the untreated male and female was 106.47 but that of the male from the treated male and female varied from 46.02 to 91.42 mg in response to treatment with different concentrations of the diflubenzuron decreasing with the increasing concentration and it differed statistically with the concentration of the insect growth regulator ($P < 0.01$).

The weight of the female obtained from the untreated male and female was distinctly more than that of the female obtained from the male and female treated with any concentration of the diflubenzuron ($P < 0.01$). In response to treatment with different concentrations, the weight of the female varied from 48.33 to 101.22 mg, tending to increase with lowering of the concentration of the insect growth regulator and it depend on the concentration ($P < 0.01$).

5.1.AIIc. Effect of diflubenzuron on biomass acquisition in pupae and adults under R.F.M. (Table-5 and Fig.- 5) :

The pupa obtained from the untreated adults acquired 152.60 mg biomass which was considerably more than that of the pupa obtained from the adults treated with residue film of any concentrations of the diflubenzuron ($P < 0.01$). In response to residue film treatment of adults with different concentrations of this insect growth regulator, weight of the pupa varied from 73.16 to 144.42 mg and it was detected to differ with the concentration of the insect growth regulator ($P < 0.01$). In this respect, data revealed that the acquisition of the biomass in pupa declined with increasing concentrations.

The male obtained from adults, not treated with the residue film of the diflubenzuron was heavier (106.47 mg) than that obtained from adults exposed to residue film of any concentration of the diflubenzuron. In response to exposure of its parents to residue film of different concentrations of this insect growth regulator, the male weight 54.67 to 96.14 mg and it appeared to decrease with increase in the concentration, but as per statistical analysis, concentrations from 0.0001 to 0.01 % affected almost indentically the biomass acquisition in male (P< 0.05) but those from 0.10 to 1.0% differently (P< 0.01) and in this range, the biomass of the male declined with the increasing concentration.

The female obtained from the untreated adults acquired more biomass (112.06 mg) than that obtained from adults treated with residue film of any concentration of the diflubenzuron (P<0.01). As regards the effect of the residue film of different concentrations of the diflubenzuron , the biomass accumulated by the female varied from 56.72 to 102.26 mg, decreasing with the increasing concentration of the residue film and the analysis of variance test revealed it to be dependent on the concentration of the residue film (P<0.01).

5.1B Effects of penfluron on growth :

Results have been presented in tables 2 & 6 and Figs. 2 and 6.

5.1B.I. Effects of penfluron on biomass accumulation in larva:

5.1B.Ia. Effects of penfluron on biomass accumulation in larva under P.D.M. (Table-2 and Fig. 2):

On the 5th day, the biomass accumulation in larva (4.30mg), not treated earlier at pupal stage with penfluron, was more than that of the larva treated earlier at pupal stage with any concentration of the penfluron (P< 0.05). On this day the larval biomass varied from 1.67 to 3.81 mg in response to treatment earlier at the pupal stage with different concentrations of the penfluron separately and decreased with increase in the concentration of the insect growth regulator. The statistical analysis revealed that on the basis of biomass accumulation in larva, these concentrations of penfluron could be arranged in three groups : the first group included 0.0001% concentration; second group included 0.001, 0.01 and 0.10% concentrations and the third group consisted of 0.50 and 1.00% concentrations. Each concentration of the second group affected the larval biomass alike and like-wise each concentration of the third group affected it identically (P< 0.05). On the basis of the larval biomass on the 5th day, the above concentrations of the penfluron could be arranged as 0.0001% > 0.001, 0.01 and 0.10% > 0.50 and 1.00%.

On the 10th day, the larva, not treated earlier at pupal stage, acquired more biomass (22.64 mg) than that treated earlier at the pupal stage with any of the concentrations of the penfluron (P< 0.01). In response to the pupal treatment earlier the larval weight varied from 6.81 to 15.73 mg among the different concentrations of insect growth regulator (0.0001 to 1.00%). The larval biomass differed with the concentrations of the penfluron significantly (P< 0.05).

The 15th day larvae, not treated earlier at the pupal stage, had far more biomass (110.93 mg) than that treated earlier at the same stage with any concentrations of the penfluron (P< 0.01). As regards the effect of different concentrations on the biomass of the 15th day larva, it decrease with increase in concentration, varying from 20.92 to 71.14 mg and depended on the concentration (P< 0.05).

5.1B.Ib Effects of penfluron on biomass accumulation in larva under A.F.M. (Table-2 and Fig. -2):

The 5th day larva, not treated earlier at adult stage orally, obtained more biomass (4.30 mg) than that obtained in response to treatment earlier at the adult stage orally with any concentration of the penfluron (P< 0.05), varied from 1.78 to 3.84 mg among different concentrations of the penfluron tending to decline with rise in the concentration of the insect growth regulator. But the statistical test showed that 0.001, 0.01 and 0.10 % concentration had similar effect on the larval biomass and like-wise 0.50 and 1.00% concentrations also affected the larval biomass on the 5th day identically (P> 0.05) but any of the 0.50 and 1.00% concentrations caused considerable reduction in the larval biomass as compared to any of the 0.0001, 0.01 and 0.10% (P< 0.05), which reduced the 5th day larval biomass as compared to 0.0001 concentration of the penfluron (P< 0.05), earlier orally with any of the employed concentration of the penflluron (P< 0.05) and on this day, in response to earlier oral treatment of its adults with the penfluron, the larval biomass varied from 6.83 to 15.76 mg among different

concentrations decreasing with increase in the concentration and it differed with the strength of the insect growth regulator (Anova P< 0.05).

On the 15th day, the larva not treated earlier at adult stage, had more weight (110.93 mg) than that of the larva obtained from adults treated orally with any of the concentration of the penfluron (P< 0.01). Under this method of treatment the larval biomass varied from 21.04 to 72.24 mg among different concentrations of the insect growth regulator and it was reduced with the increasing strength of the insect growth regulator. The analysis of variance showed that it was affected by the strength of the insect growth regulator   (P< 0.01).

5.1B.Ic. Effect of penfluron on biomass accumulation in larva under R.F.M. (Table-2 and fig.-2) :

The treatment of adults with residue film of any strength of the penfluron reduced the biomass accumulation on the 5th day in larva as compared to the untreated adults (P< 0.05). In response to adults treatment with the residue film of different concentrations of the penfluron, the larval biomass on the 5th day varied from 1.85 to 3.83 mg, tending to decrease with the increasing concentrations of the insect growth regulator but the statistical analysis revealed that the larval biomass at 0.0001% concentration (3.83 mg) was more than that at any of concentrations from 0.001 to 0.01 (2.66 to 2.96 mg); (P< 0.05) and that the larval biomass at any of the latter concentrations was more than that at any of 0.50 and 1.00% concentrations (1.85 to 2.00 mg); (P< 0.05). However, the larval

biomass at 0.50% concentration (2.00 mg) was almost similar to that at 1.00% concentration (1.85 mg) (P< 0.05).

The larva obtained from adults, not treated with the residue film of any concentration of the penfluron, was considerably heavier (22.64 mg) on the 10th day than that obtained from adults treated with residue film of any of the concentrations of the insect growth regulator (P< 0.05). The larval biomass on this day varied from 6.86 to 15.76 mg in response to adults treatment with the residue film of different concentrations of the penfluron, declining with the increasing concentration and the statistical analysis showed that the larval biomass on this day depended on the strength of the penfluron (P<.05).

On the 15th day, the biomass of the larva of the untreated adults (110.93 mg) surpassed that of the larva of adults treated with the residue film of any of the concentrations of the above mentioned insect growth regulator (P< .01). The larval biomass on this day, in response to adults' treatment with residue film of different concentrations, 6.86 to 15.76 mg, decreasing with increase in the concentrations and, as per analysis of variance test, it was found to differ with the strength of the penfluron (P< .01).

5.1B.II Effects of penfluron on biomass acquisition in pupae and adults :

Results have been listed in table 5 and fig. 5.

5.1B.IIa Effects of penfluron on biomass acquisition in pupae under P.D.M. (Table-5 and fig.- 5) :

The control pupa acquired more weight (152.60 mg) than the pupa treated earlier at the pupal stage with any of the concentrations of the penfluron used (P<01).

In response to earlier treatment of the pupa with different concentrations of the penfluron, the acquisition of biomass in pupa varied from 106.72 to 150.62 mg declining with increase in the concentration of the insect growth regulator and it was detected statistically to differ with the concentration (P< .01).

The biomass of the male adult of the untreated pupa was considerably more than that of the male adult obtained from the pupa treated with any concentration of the penfluron. It varied from 48.86 to 94.74 mg in response to treatment of its pupae with different concentrations of the penfluron reducing with the increasing concentration of the insect growth regulator. It was revealed by the analysis of variance test that the weight of the adult male differed with the concentration of the penfluron (P< .01).

Adult female of the untreated pupa was heavier (112.06 mg) than that obtained from the pupae treated with any concentration of the penfluron (P< .01). Females obtained form the pupae treated with different concentrations of the penfluron exhibited variability in their biomass; it varied form 52.00 to 103.63 mg and tended to decrease with increase in the concentration of the insect growth regulator and the computation of analysis of variance revealed it to differ with the concentration of the penfluron applied to the pupa (P< .01).

5.1B.IIb. Effects of penfluron on acquisition in pupae and adults undr A.F.M.   (Table-6 and Fig-6) :

Pupa of the untreated adults had more biomass than the pupa of the treated adult with any concentration of the penfluron (P< .01). In response to oral treatment of adults with different concentrations of the penfluron, the weight of the pupa varied from 66.20 to 135.12 mg and it depended on the concentration of this insect growth regulator with great significance (P<.01) and it decreased distinctly with the increase in strength of the penfluron (Table –6).

Weight of the male adult (106.47 mg) obtained from untreated adults exceeded that of the male obtained from adults treated orally, with any strength of the penfluron. The weight of male adults, in response of this insect growth regulator varied from 44.24 to 89.04 mg and the analysis of variance showed it to depend on the concentration of this insect growth regulator with great significance (P< .01). Further, the weight of the male adults of the treated parents showed distinct tendency towards the decrease with the increase in the concentration of the penfluron administered orally.

The biomass acquisition of the female of the untreated parents was 112.06 mg showing high increase over that of the female obtained from parents treated with any concentration of the penfluron orally. In response to its parents treatment orally with different concentrations of the penfluron, the biomass acquisition by the female adult varied from 48.10 to 98.80 mg and it differed with

the concentration of this insect growth regulator (P< .01) and it decreased with the increase in strength of the insect growth regulator.

5.1B.IIC Effect of penfluron on biomass acquisition in pupa and adults under R.F.M. (Table 6 and Fig.-6):

The pupa of the control adults was heavier (152.60 mg) than that of the treated adults with residue film of any concentration of the penfluron. The pupal weight in response to parents treated with different concentrations of the penfluron in the form of their residue film varied from 76.10 to 142.40 mg and as per Anova test it differed with the concentration of the residue film of the insect growth regulator (P< .01). Further, it tended very strongly to decrease with the prograssive increase in the concentration of the residue film of the penfluron.

The male of the untreated parents had more biomass (106.47 mg) as compared the male obtained from the parents treated with the residue film of the penfluron of any concentration. In response to its parents treated with different concentrations of the penfluron as the residue film, the weight of the male adult varied from 54.02 to 97.80 mg and according to the variance ratio computed from the data, it was found to differ with the concentration of the residue film of the penfluron applied to parents (P< .01). As regards the trend of the influence of the residue film of the penfluron in respect of different concentrations, the biomass

acquisition in the male adult decrease with the increasing strength of this insect growth regulator (Table –6).

The untreated parents adult female acquired significantly more biomass as compared that obtained from parents treated with the residue film with any concentration of the penfluron (P< .01). As regards the influence of the parent's exposure to residue film of different concentrations of the penfluron on the adult female's biomass, it varied from 55.80 to 107.40 mg among residue film of different strengths and according to Anova test, it depended on the strength of the residue film of the insect growth regulator to which the parents were exposed (P< .01). Further, with the progressive increase in the strength of the residue film, the weight of the adult female decreased accordingly (Fig. 6).

5.1C Effects of diamino-furyl-s-triazine on growth :

Result pertaining to the effect of diamino-furyl-s-triazine on the biomass accumulation in larvae and weight acquisition in pupae and adults have been given in Tables 3 and 7 and fig. 3 and 7.

5.1C.Ia. Effects of diamino furyl-s-triazine on biomass accumulation in larva under P.D.M. (Table-3 and fig. 3):

The larva, not treated earlier at the pupal stage, accumulated more biomass (4.30) than that treated earlier at the pupal stage with any concentration of the diamnino-furyl-s-triazine on the 5th day of its life (P<.01). In response to treatment with different concentrations of the diamino-furyl-s-triazine on the pupal stage, the biomass accumulated by the larva on this day varied from 1.68 to

2.70 mg and it tended to decrease with the increasing concentration of the insect growth regulator. Statistical analysis showed that the treatment with the lowest concentration (0.0001%) resulted in accumulation of more biomass than that with any of the remaining concentrations. The concentrations, 0.001% to 0.10% behaving alike in affecting the larval biomass, reduced the accumulation of biomass as compared 0.0001% concentration and like-wise, 0.50 and 1.00 concentrations, behaving identically in this respect, caused further reduction in accumulation of larval biomass.

On the 10th day of its life, the larva, not treated earlier at the pupal stage, had more biomass (22.64mg) than that treated earlier at the pupal stage with any concentration of the diamino-furyl-s-triazne (P< .01). As regards the effects of different concentrations of this chemical, applied earlier to pupae, on the accumulation of biomass in larvae on this day, the larval weight varied from 6.82 to 13.84 mg and it depended on the concentration of the diamino-furyl-s-triazine (P< .05), decreasing with increase in the concentration of this chemical.

Like the 5th and the 10th day, on the 15th day also, the larva of the control pupae had more biomass than that treated earlier at the pupal stage with any concentration of the diamino-furyl-s-triazine (P< .01). As regards the effect of the different concentrations of this insect growth regulator applied earlier to pupae, on biomass of the larva on this day, the weight of the larva varied from 20.94 to 70.46 mg among different concentrations and differed with the concentration (P< .01) decreasing with the increasing strength of inseticide.

5.1C.Ib. Effects of diamino-furyl-s-triazine on biomass accumulation in larva under A.F.M. (Table-3, fig.-3) :

On the 5th day, the larva of the untreated adults was heavier (4.30 mg) than that of adults treated orally with any of the concentrations of the diamino-furyl-s-triazine (P< .01). The larval biomass on this day in response to its adults treatment with different concentrations of the diamino-furyl-s-triazine varied from 1.79 to 3.94 mg among these concetrations tending to decrease with the increase in the concentration of this insecticide but the critical ratio computation for the significance of difference between means showed that 0.0001% concentration caused less reduction, concentrations from 0.001% to 0.10% each behaving alike, caused more reduction and 0.50 and 1.00% concentrations, each behaving alike, cause still more reduction in larval weight on this day as compared the biomass of the larva of the untreated adults and thus from the stand point of reduction in larval biomass on the 5th day the different concentrations of the diamino-furyl-s-triazine could be arranged as 0.50% or 1%, 0.10% or 0.10% or 0.0001% , 0.001%.

On the 10th day also, the larva of the untreated adults accumulated significantly more biomass (22.64 mg) than the larva of the adults treated with any concentration of the diamino-furyl-s-triazine through food (P< .01). As regards the influence of different concentrations of this chemical on biomass accumulation in the larva on this day, the weight of the larva varied from 6.88 to 15.82 mg and if differed with the concentration (P< .05), exhibiting clear

tendency towards decrease with the increase in the concentration of the insecticide.

Like the 5th and 10th day, on the 15th day also, the larva of the untreated adults accumulated much more biomass (110.93 mg) than the larva of the adults treated orally with any concentration of the diamino-furyl-s-triazine and the larval biomass, in case of adult's treatment orally with different concentrations of this insecticide, varying from 22.46 to 71.40 mg, differed with the concentration of the chemical (P< .05) decreasing progressively with its increasing concentration.

5.1C.Ic. Effects of diamino-furyl-s-triazine on biomass accumulation in larva under R.F.M. (Table –3 and Fig.-3):

The biomass accumulation in larva on the 5th or 10th or 15th day in case of its adults, not treated with the residue film of the diamino-furyl-s-triazine was considerably more than in it whose adults were treated with the residue film of any concentration of this insecticide (P< .01). On the 5th day, the weight of the larva, in response to adults' treatment with the residue film of different concentrations of the diamino-furyl-s-triazine varied from 1.74 to 3.93 mg and tended to decrease with the increasing strength of this insect growth regulator but according to the statistical analysis of the data, the concentrations from 0.001% to 0.10% behave alike in influencing the larval biomass and like-wise, 0.50 and 1.00% concentration also behaved identically in this respect. However, these

concentrations caused respectively more and still more reduction as compared the 0.0001% concentration.

In response to adults' treatment with the residue films of different concentrations of the diamino-furyl-s-triazine the larval weight on the 10th day varied from 6.93 to 15.79 mg and it differed with the strength of the residue film (P< .05), declining with the increasing strength of the insect growth regulator. Like-wise on the 15th day also, the larval biomass, varying from 22.57 to 72.36 mg among the residue films of different concentrations of the insect growth regulator and it depended on them (P< .01) decreasing with the increasing strength of the residue film.

5.1C.II Effects of diamino-furyl-s-triazine on acquisition of biomass in pupae and adults :

Results have been given in Table-7 and Fig. 7.

5.1C.IIa. Effects of diamino-furyl-s-triazine on acquisition of biomass in pupae and adults under P.D.M. (Table-7 and fig.-7) :

The pupa of the untreated pupae had more biomass (152.60 mg) as compared that of the pupa of the treated with any of the concentrations of the diamino-furyl-s-triazine (P< .01). In response to application of the different strengths of the chemical to pupae, the pupal biomass varied from 71.40 to 140.36 mg, decreasing with the increasing concentration and as per statistical analysis, the pupal biomass differed with the concentrations of the diamino-furyl-s-triazine (P< .01).

The male adult, obtained from the untreated pupa had more biomass than that obtained from the pupa treated with any concentration of the diamino-furyl-s-triazine (P<.01). Further, in response to the pupae treated with different concentrations of the diamno-furyl-s-triazine, the weight acquired by the pupa varied from 49.10 to 95.00 mg and it differed with the strength of this insect growth regulator (P< .01) declining progressively with the increasing strength of the same.

Like the male of the untreated pupa, the female adult of the untreated pupa also possessed significantly more biomass than that of the pupa treated with any of the concentrations of the diamnio-furyl-s-triazine varied from 52.16 to 104.10 mg and it depended on the concentration of the same insecticide (P< .01), showing a clear tendency towards decrease with the advancing concentration of the insect growth regulator.

5.1C.IIb. Effects of diamino-furyl-s-triazine on biomass acquisition in pupae and adults under A.F.M. (Table-7) :

The pupa of the untreated adults was significantly heavier than that of the adults treated with any concentration of the diamno-furyl-s-triazine through food (P< 0.01). The biomass of the pupa of the adults treated orally with different concentrations of this insect growth regulator varied from 64.56 to 134.38 mg and differed with these concentrations with great significance (P< .01), decreasing with the increasing concentration of the insecticide.

The male of the untreated adults (106.47 mg) surpassed that of the adults orally treated with any concentration of diamino-furyl-s-triazine (P< .01). As regards the influence of the different concentrations of this insect growth regulator applied under the above method on the acquisition of the biomass in the male adult, its biomass varied among these and it differed with them with great significance (P< .01). Further, it decrease with increase in the concentration.

The female adult of the control adult was considerably heavier (112.06 mg) than that of the adults treated with any concentration of the diamino-furyl-s-triazine through food (P< .01) and the biomass of the female, in response to its adults treated with different concentrations of this insect growth regulator, varying from 47.20 to 97.80 mg, was found to differ with the concentrations with great significance (P< 0.01). Further, it decreased progressively with the increasing strength of the insect growth regulator (Table 7).

5.1C.IIc. Effects of diamino-furyl-s-triazine on acquisition of biomass in pupae and adults under R.F.M. (Table-7) :

The pupa of the adults, not treated with the residue film of the diamino-furyl-s-triazine acquired more biomass than that of the adults treated with residue film of any concentration of this insect growth regulator (P< 0.01). With residue film of different concentrations of the diamino-furyl-s-triazine applied to its adults, the pupa exhibited a pronounced viability in the biomass acquisition : the pupal biomass varied from 78.19 to 143.64 mg among the residue films of the different concentration of this insect growth regulator and as

per analysis of variance test, it differed with the strength of the residue film applied to the adults (P< .01). Further, it was observed that as the strength of the residue film increased, the pupal biomass decreased significantly.

The control adults, not treated with the residue film of the diamino-furyl-s-triazine produced heavier male adult (106.47 mg) than those treated with residue film of any concentration of this insect growth regulator (P< .01). In response to its adults treated with the residue films of the different concentrations of the diamino-furyl-s-triazine, its weight varied from 55.40 to 97.80 mg depending significantly on the strength of the residue film (P< .01). Further, it also exhibited progressive decrease in biomass of male adult with rise in the strength of insecticides.

Like the male adult, the female adult of the untreated parents also acquired more biomass than that of those treated with the residue film of any concentration of the diamino-furyl-s-triazine (P< .01). Further, the weight of the adult female varied from 58.16 to 107.36 mg in response to treatment with residue film of different concentrations of this insect growth regulator and it differed with the strength of the residue film (P< .01). The acquisition of the biomass in female adult was inversely proportional to the strength of the insect growth regulator.

5.1D. Effects of benzoyl phenyl urea on growth :

Results have been given in tables 4 & 8 and fig. 4 and 8.

5.1D.I. Effects of benzoyl phenyl urea on biomass accumulation in larva:

5.1D.Ia. Effects of benzoyl phenyl urea on biomass accumulation in larva under P.D.M. (Table 4 and Fig. 4):

On the 5th day, except 0.0001% any other concentration of the benzoyl phenyl urea applied earlier to the pupae, caused reduction in the larval biomass as compared the untreated pupa (P< .01). In response to parent pupae's treatment with different concentration of this insect growth regulator (0.001 to 1%), the larval biomass on this day varied from 1.82 to 3.14 mg, decreasing with the increasing concentration but as per computation of the critical ratio for the significance of difference between means showed that 0.001% and 0.01% concentrations behaved alike in affecting the larval biomass and like-wise 0.5% and 1% concentrations also behaved identically in this respect being more effective than 0.01% and much more effective than 0.10% or 0.10%, concentration (P< 0.01).

On the 10th day also, the larva of the pupae treated with any concentration of the benzoyl phenyl urea was considerably lighter than that of the untreated pupae (P< 0.01). In response to its parent pupae treated with different strength of this insecticide, the larva on this day accumulated 7.36 to 16.30 mg biomass, decreasing with the increasing strength of insecticide and it differed with the concentration of the chemical (P< 0.01).

Like the 10th day, on the 15th day also, the larva of the pupae treated with any concentration of the benzoyl phenyl urea has less weight than that of the untreated pupae (P< 0.01). In response to the treatment of the parent

pupae with different strengths, the larval biomass on this day varied from 28.35 to 75.23 mg declining with the rise in the concentration and it differed from concentration to concentration (Anova, P< 0.01).

5.1D.Ib. Effects of benzoyl phenyl urea on biomass accumulation in larva under A.F.M. (Table 4 and Fig. 4) :

The larva of the adults treated orally with different concentrations of the benzoyl phenyl urea, except 0.0001% had lesser biomass on the 5th day as compared to that of the untreated adults. The larval biomass on this day, in response to the parents' treatment orally with different effective concentrations (0.001% to 1%) of the benzoyl phenyl urea, varied from 1.86 to 3.26 mg, decreasing with the increasing concentration of the chemical. However 0.001% and 0.01% concentration behaved alike in effecting the larval biomass, producing heavier larva as compared the higher concentrations which caused distinct difference between biomasses (P< .01).

On the 10th day, the larva of the adults treated orally with any concentration of the benzoyl phenyl urea was considerably lighter than that of the untreated parents (P< .01). In response to parents' treatment with different concentrations of this insect growth regulator, the larval biomass on this day, showing a tendency towards decrease with the advancing concentration, varied from 7.90 to 16.18 mg and it depended on the concentration of the fourth generation insecticide.

Like the 10th day, on the 15th day also, each concentration of the benzoyl phenyl urea under adult feeding method reduced the larval biomass as compared the non-treatment situation (P< .01). As regards the effect of the different concentrations of this insecticide the larval biomass on this day, tending to decrease with the advancing concentration, varied from 29.62 to 76.80 mg and, as per analysis of variance, it differed with the concentration of the chemical (P< .01).

5.1D.Ic. Effects of benzoyl phenyl urea on biomass accumulation in larva under R.F.M. (Table 4) :

On the 5th day, the larva of the parents treated with the residue film of any concentration of the benzoyl phenyl urea, except 0.0001% was considerably lighter than that of the untreated parents (P< 0.01). In response to parents' treatment with the residue film of the different concentrations, excluding that of the 0.0001% strength, the larval biomass on this day, decreasing with the increasing concentration, varied from 2.20 to 3.26 mg and it depended on the concentration with identical effect of 0.001% and 0.01% concentrations.

On the 10th day, the larva of the parents treated with the residue film of any concentration or benzoyl phenyl urea accumulated less mass than that of the untreated parents (P< 0.01). The treatment of the parents with the residue film of different concentrations of this fourth generation insecticide caused variation in the larval biomass on this day : it varied from 6.86 to 16.28 mg among different concentrations with a tendency towards decrease with the

advancing concentration as per analysis of variance, it differed from concentration to concentration (P< 0.01).

On the 15th day also, the larva of the untreated adults had more biomass (110.93 mg) than that of the adults treated with the residue film of benzoyl phenyl urea of any concentration (P< 0.01). The larva acquired 30.26 to 77.90 mg biomass in response to its parents treatment with the residue film of different concentrations of this insecticide with a tendency of reduction with the increasing concentration and, it was found to depend on the concentration (Anova, P< .01).

5.1D.II Effects of benzoyl phenyl urea on acquisition of biomass in pupae and adults :

Result have been presented in table 8 and fig. 8.

5.1D.IIa. Effects of benzoyl phenyl urea on acquisition of biomass in pupae and adults under P.D.M. (Table 8 and Fig. 8) :

The pupa of the untreated parent pupae acquired more weight than that of the parent pupae treated with any concentraion of the benzoyl phenyl urea (P< .01). In response to the parent pupae's treatment with the different concentrations of the benzoyl phenyl urea the pupal biomass, decreasing, with the increasing concentraion, varied from 101.45 to 148.62 mg, and it depended on the concentration of the chemical (P< .01).

The male and female adults of the untreated pupae, acquiring 106.47 and 112.06 mg biomass respectively, were heavier than those of the pupae

treated with any concentration of the benzoyl phenyl urea (P< .01). In response to their parent pupae's treatment with different concentrations of this chemical, the biomasses of male and female adults, varying from 56.36 to 101.86 mg and from 62.02 to 108.82 mg respectively and the both decreasing with the increasing concentraion, were found to be strongly affected by the concentraion (P< .01).

5.1D.IIb Effects of benzoyl phenyl urea on biomass acquisition in pupae and adults under A.F.M. (Table 8) :

The pupa of the adults treated orally with any concentration of the benzoyl phenyl urea was lighter than of the untreated adults (P< .01). In response to its parent adults treated with different strengths of this insecticide the pupa acquired 95.22 to 142.84 mg biomass, decreasing with the increasing concentration, differed from strength to strength of this insecticide (P< .01).

The male and female adults of their treated parent adults orally with any concentration of the above mentioned chemical acquired considerably less biomass as compared to those of the untreated parent adults (P< .01). In response to their parent adults treatment orally with different strengths of the benzoyl phenyl urea, their biomass, varying from 48.86 to 96.44 mg and from 57.71 to 101.84 mg respectively and, both decreasing with the increase in the concentration of the chemical, were affected differently by the different strengths of this insecticide (P< .01).

5.1D.IIc. Effects of benzoyl phenyl urea on biomass acquisition in pupae and adults under R.F.M. (Table 8, Fig 8) :

The pupa of the untreated adults acquired more biomass than that of the adults treated with the residue film of the benzoyl phenyl urea of any concentration (P< .01). In response to its parent adults treated with residue films of different concentrations of this chemical, the pupa obtained 107.60 to 153.82 mg biomass, falling with the rising concentration and the pupal biomass, as per Anova test, was found to differ strongly with the concentration of this chemical (P< .01).

The male of the untreated parent adults was considerably heavier (106.47 mg) than that of the parent adults treated with the residue film of any concentration of benzoyl phenyl urea (P< .01). In response to its parents adult treatment with the residue film of different concentrations of this chemical, the biomass of the male adult varied from 62.43 to 105.22 mg, decreasing with the increasing concentration and, as per analysis of variance, it depended strongly on the concentration of the benzoyl phenyl urea (P< .01).

The female adult of the adults treated with the residue film of the benzoyl phenyl urea of any concentration acquired less biomass as compared that of the untreated adults (P< .01). As regards the effect of the parent adults treated with the residue films of the different concentration of this chemical on the biomass of the adult female, the weight of the female adult varied from 67.85 to 113.62 mg, tending to decrease with the rise in the concentration and it was affected differently by the different concentrations (P< .01).

5.2. EFFECTS OF INSECT GROWTH REGULATORS ON FOOD CONSUMPTION:

Results have been presented in Tables 9-12 and fig. 9-12.

5.2.A. Effects of diflubenzuron on food consumption:

Results have been given in Table 9. In the larval feeding treatment, the chemical suppressed the rate of food consumption in treated larvae at higher concentration level but at lower level, the chemical was less effective in reduction the food consumption. The maximum reduction in food consumption recorded was 43.40 per cent at 1.00 per cent level and minimum being 20.95 per cent at 0.0001per cent level in test. The food digested by the treated larvae was also reduced with the increase in concentration level and was recorded 67.75 per cent maximum at 0.0001 per cent, in comparison to control which showed food digestion of 70.93 per cent.

5.2.B Effects of penfluron on food consumption:

Results have been given in Table 10. Observations were done to see the effect of the consumption of the amount of food consumed by the treated larvae. Data indicated a significant reduction in food consumption with increase in treatment level. The food intake was adversely affected and was reduced maximum by 41.22 per cent at 1.00 per cent level of feeding. There was a marked increase in reduction of food consumption at each concentration in test, from 0.0001 to 1.0 per cent level. Minimum reduction in food consumption was 20.55

per cent at 0.0001 per cent level. Food digestion was reduced by 29.71 per cent at 1.0 per cent level. The reduction in food consumption and food digested.

5.2.C Effects of diamino-furyl-s-triazine on food consumption:

Results have been presented in Table – 11. In the larval feeding treatment, the chemical suppressed the rate of food consumption in treated larvae at higher concentration level, but at lower level, the chemical was less effective in reducing food consumption. The maximum reduction recorded was 44.44 per cent at 1.0 per cent level in test. The food digested by treated larvae was reduced with the increase in concentration level and was recorded 36.26 per cent maximum at 0.0001 per cent level, in comparison to control which showed food digestion of 70.93 per cent.

5.2.D. Effects on benzoyl phenyl urea on food consumption:

Results have been given in Table – 12. The data shows that the food intake was considerably reduced by the treated larvae at various concentration levels. At lower levels, the chemical was also effective in reducing the food consumption but higher concentration drastically reduced the food intake capacity. Maximum reduction was exhibited at 1.00 per cent level and was 45.22 per cent. Food digested at 0.0001 per cent level was also affected in comparison to control that is recorded 70.93 per cent. So the chemical exhibited suppression

in the rate of food consumption & digestion when administered with the food. This resulted in the inability in feeding by treated larvae.

5.3 EFFECTS OF INSECT GROWTH REGULATORS ON POST-EMBRYONIC DEVELOPMENT:

Results have been presented in Tables 13 to 20 and fig. 13-20.

5.3 A. Effects of diflubenzuron on post embryonic development:

Results have been given in Tables 13 to 20.

5.3 A.a Effects of diflubenzuron on post-embryonic development under P.D.M.

(Table 13 to 17): The larvae of the adults of the untreated pupae had considerably more survival (83.33%) as compared those of the adults of the pupae treated with any concentration of the diflubenzuron (P<.01). In response to treatment of pupae, the survival of the larvae varied from 30 to 66.66% decreasing with the increasing concentration of the chemical. But according to the statistical analysis, the percentage of the survival depended on the strength of the insecticide from 0.0001 to 0.50% and the effect of the 1.00% concentration was not statistically different from that of the 0.50% (P< 0.5). Further, the duration of the larvae in response to non-treatment of their pupae was just 15 days, whereas this duration varied from 18.25 to 36.73 days in response to the pupae treated with different concentrations of this insecticide, appearing to increase with the increasing concentration. However, as per statistical analysis, concentration from 0.0001% to 0.10% did not influence the larval period differently (P<.05) but

0.50% and 1.00% concentration delayed the larval development considerably as compared any concentration from 0.001% to 0.10% and the latter of the two caused more delay (P < 0.01).

The pupa, not treated at the ancestral pupal stage exhibiated 100 per cent emergence, whereas that treated at the same stage with any strength of the diflubenzuron had far reduced emergence (P<0.01). In response to ancestral pupea's treatment with the different concentrations of this insect growth regulator, the emergence, varying from 16.66 to 60%, tending to decrease with increasing concentration, differed significantly with the strength of this fourth generation insecticide (P< 0.01). Further, the duration of the pupa of the untreated ancestral pupae (11.64 days) was considerably shorter than that of the pupa of the ancestral pupae treated with any concentration of the diflubenzuron except 0.0001% (13.93 days or more than its two times, (P< 0.01).

The net mortality (Table 17) under the pupal dip treatment varied from 52 to 94% increasing with the advancing concentration and the x^2 test detected it to depend on the concentration level (P< 0.05).

The male adults obtained from the untreated pupae had life-span more as compared the male adult obtained from the pupae treated with any concentration of the diflubenzuron and this fact was applicable to the female adult also (P<0.05) . The longevity of the male adult, varying from 3.54 to 9.30 days and that of the female adult, varying from 4.38 to 13.48 days, tended to decrease with the increase in the concentration of the insecticide. However, the statistical analysis

revealed that 0.0001% and 0.001% concentrations, inducing more longevity in the both sexes as compared any of the remaining concentrations, behaved identically in affecting the life of either sex differed with the concentrations from 0.01% to 1.00% ($P < 0.05$).

5.3 A.b **Effects of diflubenzuron on post-embrynoic development under A.F.M. (Table 13 and 17) :** The larva of the untreated adults acquired 83.33% survival, whereas that of the adults treated orally with any concentration acquired survival in the range between 28 and 69% ($P<0.05$). In response to adults oral treatment with different concentrations of the chemical, results showed that the larval survival, varying from 28.33 to 68.33% and decreasing with the advancing concentration level, depended on the concentration level of the diflubenzuron ($P<0.05$). Further, the larva of the untreated adults grew faster than that of the adults treated with any concentration of the diflubenzuron ($P< .01$). As regards influence of different concentrations of this insect growth regulator administered orally in adults, the duration of the larval stage, varying from 18.36 to 34.86 days and increasing with the increasing concentration, was detected to depend on the concentration level ($P< .05$). Further, the pupa of the untreated adults had 100% emergence which was much curtailed in case of the pupa of the adults treated orally with any concentration of this insect growth regulator. In response to adults oral treatment with different concentrations of this insecticide the percentage of the emergence, varying from 17.67 to 60.98% and decreasing with the increase in the concentration, was detected to differ with the concentration ($P<0.05$). There

was no significant difference in the pupal period between the non-treatment condition and the treatment situation at 0.0001% (P > 0.05) but above this strength, the pupal period was prolonged considerably by any of the remaining concentrations (P<0.05). In response to adults oral treatment with different concentrations form 0.001% to 1.00%, the pupal period, varying from 13.90 to 29 days and increasing with the increase in the concentration level, depended significantly on the strength of the insecticide (Anova, P< 0.05). Further, the results pertaining to the net mortality revealed that in response to adults' oral treatment with different concentrations of the diflubenzuron as per chi-sqare test it varying from 50 to 94% and increasing with the rise in the strength of the insect growth regulator, differed significantly with the concentration (P<0.05).

The parent adults oral treatment with any concentration of the diflubenzuron curtailed as compared parent adults' non-treatment (Anova P<0.05). The female lived longer than the male in response to their parents' treatment with any concentration of the chemical. The life span in either sex, decreasing with the increasing concentration level, differed with the increasing concentration of the insect growth regulator (P<0.05).

5.3A.c **Effects of diflubenzuron on post-embryonic development under R.F.M.** **(Table 13 to 17) :** The larva of the parents treated with residue film of any strength of the diflubenzuron acquired lesser survival than the larva whose parents remained untreated (P<.05). In response to parents' treatment with the residue films of this insecticide, the percentage of pupation, varying from 28.33

to 68.33% and decreasing with the advancing concentration depended on the concentration (P<0.05), and the duration of the larva, being prolonged with the residue film of any concentration of this chemical as compared the non-treatment condition (Anova, P<0.05), varying from 18.42 to 36.36 days in response to residue films of different strength and prolonging with the rise in the strength level, also differ with the concentration level of the diflubenzuron (Anova, P<0.05). Further, the parents' treatment with the residue film of any concentration of this chemical affected the percentage of the emergence (P<0.05) which varying from 20 to 66.67% among residue film of different concentrations and tending to fall with the rise in the strength of the residue film, was found to depend on the concentration level of the residue film applied to the parents (Anova, P<0.05). The pupal duration with the 0.0001% concentration was not more as compared that under the non-treatment condition (P>0.05) but the residue film of any other concentration prolonged this concentration (P<0.05). As regards the influence of the residue film of different concentrations (0.001% to 1.00%) on the pupal period, it, varying from 13.50 to 27.40 days and increasing with the rising concentration level, differed significantly from concentration to concentration (P<0.05).

The adult male progeny of the untreated parents had more longevity as compared that of the parents treated with the residue film of any concentration of the diflubenzuron   (Anova, P<0.05). The longevity of the adult male progeny, in response to treatment of its progenitor adults with the residue films of different

concentration of this insecticide varying from 5 to 9.76 days and declining with the advancing concentration, depended on the concentration of the chemical ($P<0.05$). In case of female adult's longevity barring 0.0001% the remaining residue films of different concentrations caused reduction in the longevity ($P< 0.05$) and it was affected differently by the residue films of different strengths (Anova, $P<0.05$), decreasing with the increase in the strength of the residue film of this insect growth regulator.

5.3B **Effects of penfluron on post-embroyonic development:**

Results have been presented in Tables 14 and 18.

5.3B.a **Effectes on penfluron on post-embroyonic development under P.D.M. (Tables 14 to 18):** The larva treated earlier at the pupal stage with any strength of the penfluron had considerably reduced survival than that not treated earlier at the pupal stage ($P< 0.05$). In response to treatment earlier at the pupal stage, the larval survival, varying from 31.66 to 70% among different concentrations and tending to decrease with the increasing concentration level, differed with the strength of the penfluron (Anova, $P<0.05$). Further, the treatment with the penfluron earlier at the pupal stage prolonged the larval duration considerably as compared the duration of the larva of the untreated pupae (Critical ratio, $P< 0.05$). In response to treatment earlier at the pupal stage with different concentrations of the penfluron the larval period varied from 18.25 to 36.06 days and tended to be directly proportional to the concentration, but 0.0001, 0.001 and 0.10% concentration affected the larval period identically ($P>0.05$) with relative less

prolonging as compared concentrations from 0.10 to 1% with which the larval development was more delayed, depending on the strength (P< 0.05).

The pupa of the control parent pupae acquired 100% emergence whereas that of the earlier treated parent pupae, acquired far less emergence, below 62%. In response to parent pupae's treatment with different concentrations of the penfluron, the emergence, varying from 26.32 to 61.90% and appearing directly proportional to the concentration, differed from one concentration to another statistically (P<0.05). Further, barring 0.0001% concentration, all other concentrations prolonged the pupal period and among these concentrations, this duration, varying from 13.90 to 28.42 days, and tending to prolong with the increasing strength, was detected statistically to depend on the concentration of the penfluron (Anova, P< 0.05).

The net mortality under the pupal dip method of the application (Table-18) varied from 48 to 90%, showing a tendency towards increase with the increasing concentration and as per Chi-square test, it differed with the concentration of the penfluron (P<0.05). Further, under PDM application, all concentrations curtailed the life-span of both male and female adults and in either sex, the longevity (4.64 to 9.74 days in male and 4.44 to 13.48 days in female), showing indirect proportionality to the concentration, differed from one concentration to another (Anova, P< 0.05).

5.3 B.b **Effects of penfluron on post-embryonic development under A.F.M. (Table 14 to 18):**

The adults' oral treatment with any concentration of the

penfluron caused reduction in the larval survival as compared adults' non-treatment ($P<0.05$). The larval survival, in response to adults' oral treatment, varying from 31.66 to 70% and appearing to increase with the increasing concentration levels was found to depend on the concentration applied to adults ($P < 0.05$). The adults' oral treatment with any strength prolonged the larval development as compared the untreated adults ($P< 0.05$).

In response to parents' treatment orally with different concentrations of the penfluron, the larval period varied from 18.34 to 34.82 days and appeared to be directly proportional to the concentration, but the statistical analysis revealed that the effect of 0.0001 to 0.10% concentration is alike ($P>0.05$) and the larval period differed significantly among concentrations from 0.0001 to 1% and it increased with increasing strength in this range ($P< 0.05$).

Parents' oral treatment with any concentration of the penfluron curtalied the emergence considerably ($P< 0.05$) as compared the untreated situation. In response to treatment of adults with different concentrations of this fourth generation insecticide, the emergence, varying from 17.17 to 60.98% and exhibiting a direct proportionality to the concentration, differed with the concentration ($P<0.05$). Further, the penfluron of any concentration prolonged the pupal stage as compared the situation without this insecticide ($P< 0.05$ or 0.01). Tending to prolong with the increasing concentration levels, the pupal period varied from 12.70 to 29 days among different concentrations and it was detected statistically to depend on the concentration ($P< 0.05$).

Under adult feeding method, the net mortality, increasing with the concentration of the penfluron varied from 33 to 55% and differed from concentration to concentration (P< 0.05).

The oral treatment of the parent adults with any concentration of the penfluron reduces the longevity in both sexes (P< 0.05) and in either sex, the longevity (4.52 to 9.64 days in male and 5.62 to 12.58 days in female) differed with the concentration (P< 0.05) and exhibited indirect proportionality to the concentration.

5.3 B.c Effects of penfluron on the post-embryoinc development under R.F.M (Table 14 & 18) :

The treatment of the parents with residue film of any concentration of the penfluron induced larval survival significantly as compared the untreated parents (P< 0.05). As per chi-square test the larval survival varying from 33.32 to 71.67% among the different concentrations of this insecticide and decreasing with the increasing concentration depended on the concentration level (P<0.05). Further, the parents' residue film treatment with any concentration of the penfluron prolonged the larval stage as compared the duration of the larva of the untreated parents (P< 0.05). In response to parents' residue film treatment of the penfluron, the larval period, varying from 18.26 to 33.32 days among different concentrations and appearing to be directly proportional to the concentration, was affected identically by 0.0001, 0.001 and 0.01 concentrations (P> 0.05) but it differed significantly with the remaining concentrations and in this respect, any concentration from 0.0001 to 0.01 delayed

the larval development less as compared any concentration from 0.10 to 1% (P< 0.05).

Under R.F.M. 0.0001% concentration of the penfluron did not affect the pupal period as compared the non-treatment situation (P> 0.05) but the concentration level above this, which caused the pupal period to be from 15.40 to 26.24 days among them, affected this period differently (P<0.05) and the increase in the strength caused the increase in the pupal duration. Further, all the concentrations applied by R.F.M. considerably reduced the emergence as compared the non-treatment condition (P< .05). The results revealed that the emergence (30 to 65.12%) decreased with the increasing concentration level.

Further, the net mortality, varying from 44 to 88% among residue films of different concentrations of the penfluron appearing to be directly poportional to the concentrations, depended on the concentration of the residue film (P< 0.05).

The parents' treatment with residue film of any concentration of the penfluron reduced the life-span of progeny adults of the both sexes as compared the untreated parents (P<0.05). In either sex, the longevity of the progeny adults, varying differently with the concentration of the residue film of this insect growth regulator (P< 0.05) and decreased with the advancing concentration of the residue film.

5.3 C. Effectes of diamino-furyl-s-triazine on post-embryonic development:

Results have been given in Table 15 and 19 and Fig 15 and 19.

5.3 C.a Effects of diamino-furyl-s-triazine on post embroyonic development under P.D.M. (Tables 15 and 19) : The larva obtained from the adults of the pupae dipped in any concentration the diamino-furyl-s-triazine had curtailed survival as compared to that obtained from the adults of the untreated pupae ($P<$ 0.05). In response to parent pupae's dipping in the diamino-furyl-s-triazine the larva acquired 33 to 71.66% survival, among different concentrations decreasing with the increase in the concentration and, it depended on the concentration of the insect growth regulator. Further, under P.D.M. any concentration of the diamino-furyl-s-triazine prolonged the larval stage in comparison to non-treatment situation ($P<$ 0.05) and under this method of treatment, the larval period, varying from 18.20 to 32.40 days among different concentrations of the diamino-furyl-s-triazine and prolonging with the increasing concentration was not affected differently by concentrations from 0.0001 to 0.10% but it differed with the concentrations from 0.10 to 1% and any of these concentrations prolonged this period more as compared 0.0001%, 0.001%, 0.01%.

Any concentration of the diamino-furyl-s-triazine applied by pupal dip method induced for less emergence than the untreated situation ($P<$ 0.05). The emergence, varying from 20 to 62.79% among different concentrations applied by the above method and decreasing with the increasing concentration level, was dependent on the strength of the insecide ($P<$ 0.05). Like wise any concentration level of the above insecticide by P.D.M., prolonged the pupal duration in comparison to the non-treatment situation ($P<$ 0.05). In response to treatment of

different concentrations of the diamino-furyl-s-triazine the pupal period, varying from 12.0 to 27.26 days among them, appeared to increase with the increasing concentration but as per statistical analysis, the concentrations from 0.0001 to 0.01% exerted almost similar effect on the pupal period (P> 0.05) but the concentrations from 0.10 to 1% affected this period differently (P< 0.05), exerting more prolonging effect in comparison to 0.0001% or 0.001% or 0.01% concentration (P < 0.05).

The net mortality under pupal dip method, varying from 46 to 92% among different concentration of the diamino-furyl-s-triazine showing direct proportionality to the concentration was detected statistically to depend on the concentration of the diamino-furyl-s-triazine (P< 0.05).

In response to the treatment of parent pupae with any concentration of the diamino-furyl-s-triazine, the longevity of both male and female adults was curtailed as compared the untreated condition of the parent pupae (P< 0.05). The life-span of the adult of either sex, varying from 5.14 to 9.62 days in male and from 6 to 13.76 days in female and, decreasing with the increasing concentration level depended on the concentration of the chemical (P< 0.05).

5.3C.b Effects of diamino-furyl-s-triazine on post-embryonic development under A.F.M. (Table 15 & 19) : The larva of the untreated adults acquired more emergence than that of the adults treated with any concentration of the diamino-furyl-s-triazine through food (P<0.05). In response to parent adults' oral treatment with different concentrations of this fourth generation insecticide, the larval

survival, varying from 31.66 to 71.66% and tending to decrease with the advancing concentration levels, was detected statistically to depend on the concentration of the insecticide (P< 0.05). Like wise, under A.F.M. any concentration of this insecticide prolonged the larval stage in comparison to the untreated adults (P< 0.05). In response to the treatment of the adults orally with different concentrations of this insecticide, the larval period varied from 18.20 to 31.50 days and showed a direct proportionality to the concentration but the statistical analysis revealed that the concentrations from 0.0001 to 0.01% influenced this period identically (P< 0.05) and the concentrations from 0.10 to 1% affected the larval duration differently (P < 0.05) with more protraction in comparison to any of the former concentrations (P < 0.05).

The pupa of the untreated adults acquired far more emergence in comparison to that of the adults treated with any concentration of the diamino-furyl-s-triazine through food (P< 0.05). In response to oral treatment of adults with different concentrations of the diamino-furyl-s-triazine the emergence, varying from 21.66 to 65.60% and tending to be directly proportional to the concentration differed significantly from concentration to concentration (P<0.05). Under this method of treatment, barring 0.0001% concentration, other concentrations prolonged the pupal stage as compared the pupa of the untreated adults (P< 0.05) and in response to adults' oral treatment with these concentrations of this insecticide, the pupal period, increasing with the advancing concentration

and varying from 13.60 to 26.56 days, was detected statistically to depend on the concentration of the diamino-furyl-s-triazine (P< 0.05).

Under A.F.M. the net mortality increasing with the advancing concentration levels and varying from 44 to 92.0% among different concentrations. The net mortality differed with the concentration of the diamino-furyl-s-triazine significantly (P< 0.05).

The oral treatment of parent adults with any concentration of the above mentioned chemosterilant reduced the life-span of progeny adults of both sexes as compared the untreated parent adults (P< 0.05) and, in response to parent adults treatment with different concentrations of the diamino-furyl-s-triazine through food, the longevity of adults, varying from 4.26 to 9.72 days in male and from 6.42 to 12.82 days in female, tended to decrease with the advancing concentration levels. According to the statistical analysis, considering their longevity curtailing effect, these concentrations of the diamino-furyl-s-triazine could be arranged as 1%> 0.50%, 0.10% > 0.01% or 0.001% or 0.0001%.

4.2C.c Effectes of diamino-furyl-s-triazine on post-embryonic development under R.F.M. (Table 15 & 19) : The larva of the untreated adults acquired considerably more pupation than that of the adults treated with the residue film of any concentration of the diamino-furyl--s-triazine (P< 0.05). The pupation, varying from 35 to 79.33% among residue film of different concentrations and tending to decrease with the advancing concentration the larval survival was affected significantly by the residue film concentration (P<0.05). In response to

parent adults' treatment with residue films of different concentrations, the duration of the larval stage varied from 18.30 to 30 days and showed a tendency of protraction with the increasing concentration but statistical analysis revealed that the concentrations from 0.0001% to 0.01%, causing relative less prolongation of the larval stage as compared to any concentration from 0.10 to 1% behaved alike in prolonging the larval stage and that the latter concentrations acted differently in prolonging the larval stage, which was higher with more concentration (P< 0.05).

The treatment of parent adult with residue film of any strength of the diamino-furyl-s-triazine reduced emergence and, prolonged the pupal period, in general, as compared the untreated condition (P< 0.05). Among residue films of different concentration of this insecticide, the emergence, varying from 23.81 to 65.91% and appearing to be indirectly proportional to the concentration, was detected statistically to differ with concentrations (P< 0.05). Like-wise, the pupal period, which varied 13.60 to 25.66 days among residue film concentrations from 0.001 to 1% and tended to be directly proportional to the strength of the residue film, was found to be effective differently by the reside films of different concentrations (P< 0.05).

The net mortality, varying from 42 to 90% and showing direct porportionality to the concentration, differed significantly with the residue films of different concentrations of the diamino-furyl-s-triazine (P< 0.05).

The treatment of parent adults with residue film of any concentration of the diamino-furyl-s-triazine reduced the longevity in adults of both sexes as compared the untreated parent adults (P< 0.05). The life-span of progeny adult in either sex, varying from 4.46 to 9.76 days in male and from 6.94 to 13.76 days in female in response to residue films of different concentrations and tending to be indirectly proportional to the residue film concentration, differed significantly with the strength of the residue film of the diamino-furyl-s-triazine (P< 0.05).

5.3 D. Effectes of benzoyl phenyl urea on post embryonic development :

Results have been presented in tables 16 & 20 and fig 16 and 20.

5.3 D.a Effectes of benzoyl phenyl urea on post-embryonic development under P.D.M. (Table 16 & 20) :

Any concentration of the benzoyl phenyl urea except 0.0001% applied earlier to the pupal stage reduced the larval survival and delayed the pupation as compared the untreated condition of pupae (P< 0.05). The larval survival, varying from 43.33 to 71.66% among different concentrations from 0.001% to 1% and appearing to be indirectly proportional to them, was affected differently by different concentrations of the benzoyl phenyl urea (P<0.05). Further, the larval period, varying from 16.50 to 23.50 days and prolonging with the advancing concentration of the benzoyl phenyl urea, differed from concentration to concentration applied earlier to the pupae (P<0.05).

Under P.D.M., the emergence was curtailed significantly by any concentration of the benzoyl phenyl urea (P< 0.05) and the pupal period was also

prolonged significantly by any concentration of this insecticide other than 0.0001% (Anova, P< 0.05). In the concentration range of 0.001% to 1% benzoyl phenyl urea, the emergence, varying from 30.76 to 66% and tending to decrease with the increasing concentration, differed from concentration to concentration significantly and like wise, the pupal period varying from 12.33 to 20 days among concentrations from 0.001% to 1% also depended on these concentrations but it exhibited the direct proportianality to the concentration of the benzoyl phenyl urea under pupal dip treatment.

In response to the different concentrations of the benzoyl phenyl urea applied earlier to parent pupae, the net mortality varying from 34 to 84% and increasing with the advancing concentration, differed significantly from concentration to concentration (P< 0.05).

The treatment of the parent pupae with any concentration of the benzoyl phenyl urea curtailed the longevity of progeny male adults (P< 0.05). The concentrations from 0.0001% to 0.001% affected the life-span of male but other concentrations of the benzoyl phenyl urea among which the longevity of the male varied from 5.36 to 8.88 days, affected it differently (P< 0.05), causing progressive reduction. Barring the concentrations 0.0001% and 0.001% any other concentration of the benzoyl phenyl urea applied to parent pupae reduced the longevity of the progeny female adults (P< 0.05) which exhibited indirect proportionality to the concentration of the benzoyl phenyl urea.

5.3 D.b.   Effectes benzoyl phenyl urea on post-embryonic development under A.F.M. (Tables 16 & 20) : Any concentration of the benzoyl phenyl urea applied by A.F.M. reduced the larval survival and prolonged the larval development as compared the untreated condition of adults (P< 0.05). The larval survival and the larval period varying from 41.66 to 81.86% and from 16.62 to 23.24 days respectively in response to different concentrations of the benzoyl phenyl urea applied to parent adults, differed from concentration to concentration (P< 0.05). The former exhibited indirect proportionality to the concentration but the latter was directly proportional to the same.

The oral treatment of parent adults with any concentration of the benzoyl phenyl urea reduce the emergence (P< 0.05). The emergence under A.F.M., varying from 32 to 67.35% among different concentrations of this insecticide and tending to be directly proportional to the concentration, was affected differently by the different concentrations (P< 0.05). Further, any concentration other than 0.0001% under this method of treatment, the pupal period was prolonged (P<0.05). Among the effective concentrations from 0.001% to 1% the pupal period varying from 12.34 to 19.92 days and prolonging with the advancing concentration, differed with the different concentrations (P< 0.05).

Increasing with the concentration level, the net mortality, differed significantly among different concentrations of the benzoyl phenyl urea under A.F.M. (P< 0.05).

Every concentration of the above mentioned benzoyl phenyl urea aplied to the Pericallia ricini by adult feeding method reduced the life-span of the porgeny male adult (P<0.05). The concentrations 0.0001% and 0.001% reduced the male's longevity identically (P> 0.05) but the remaining concentrations from 0.01 to 1% among which the longevity varied from 5.00 to 8.90 days, reducing with the increasing concentration, affected the male's life-span differently (P< 0.05). In case of female, barring 0.0001% and 0.001% concentrations any of the remaining concentration (0.01 to 1%) applied by A.F.M. , reduced the longevity (P< 0.05) and among these concentration, it tending to decrease with the advancing concentration, was affected differently (P< 0.05).

5.3 D.c Effects of benzoyl phenyl urea on postembryonic development under R.F.M. (Tables 16 & 20) : Except 0.0001% residue film, the residue films of other strength of the benzoyl phenyl urea reduced larval survival significantly (P<0.05). As regards the influence of residue films of the effective concentrations of this insect growth regulator on the pupation these concentrations affected the larval survival differently (P< 0.05) and the pupation declined with the advancing concentration of the residue film. The residue film of any concentration of the benzoyl phenyl urea prolonged the larval stage. The larval period, varying from 16.28 to 23 days and prolonging with the increasing concentration of the residue film, depended significantly on the residue film of different concentrations of the benzoyl phenyl urea (P< 0.05).

Barring 0.0001% concentration, the residue film of any of the other concentrations prolonged the duration of the pupa (P< 0.05). Among the residue films of different effective concentrations, the pupal period, varying from 12.33 to 19.87 days and prolonging with the increasing strength, differed significantly with these concentrations (P< 0.05). The residue film of every concentration reduced the emergence (P< 0.05) which varying from 33.33 to 68% among different strengths and prolonging with the advancing concentrations was detected to differ with residue films of different concentrations of the benzoyl phenyl urea (P < 0.05).

The net mortality, varying from 32 to 82%, among reside films of different concentration of the benzoyl phenyl urea and decreasing with the increasing concentration, was found to be dependent on the concentration of the residue film as per chi-square test (P< 0.05).

Every concentration of the benzoyl phenyl urea applied as residue film to the adult reduced the life-span of both male and female adults (P< 0.05). As regards the influence of different concentrations of the benzoyl phenyl urea as residue films on the longevity of adults, it varying from 6.50 to 10.42 days in male and from 6.92 to 13.20 days in female and declining with the advancing concentration, differently with the concentration of the residue film (P< 0.05).

5.4 EFFECTS OF INSECT GROWTH REGULATORS ON REPRODUCTION :

Results have been presented in Tables from 21 to32 and Fig 21 to 32.

5.4 A. Effects of diflubenzuron on reproduction:

Results have been given in Tables 21 to 32 and Fig 21 to 32.

5.4 A.a Effects of diflubenzuron on reproduction under P.D.M. (Tables 21, 25, 29) :

The sexual maturity of the adult, in response to treatment earlier at the pupal stage with any concentration of the diflubenzuron was delayed (P< 0.05). In this respect, the concentrations from 0.0001% to 1% affected the preoviposition period (3 to 3.04 days) identically (P > 0.05) with less prolonging effect as compared to any of the concentrations from 0.0001% to 1% which delayed this period more but identically. The different concentrations of this insect growth regulator applied earlier to pupae, shortened the oviposition period markedly (P< 0.05 or 0.01) but on the basis of the statistical analysis considering their curtailing effect on the oviposition period, these concentrations could be arranged as 0.0001% or 0.001% or 0.01% or .10% or 0.50% or 1%.

The treatment of any concentrations of the diflubenzuron by the P.D.M. reduced the fecundity significantly (P<0.01). The concentrations from, 0.0001% to 0.01%, exerting almost identical effect on the fecundity (221.2 to 226 eggs/ female, P> 0.05) caused less decline in the fecundity as compared any of the other strengths 0.10% to 1% (P< 0.01). Among the concentrations (0.0001% to 1%), the fecundity, varying from 77.4 to 166.2 eggs/female and declining with higher concentration, differed strongly with them (P< 0.01). The treatment of the insect

by the P.D.M., reduced the percentage of hatching/female as compared the untreated condition (P< 0.05). The percentage of hatching, varying from 33.3 to 86.2% and decreasing with the increasing concentration under the P.D.M. differed significantly from concentration to concentration $\left(X^2 - P < 0.05\right)$.

Every concentration of the diflubenzuron applied by the P.D.M., prolongs the incubation period (P< 0.05 in case of .0001%, .001% and .01% concentrations and P< 0.01 in case of 0.10 to 1.00% concentrations). The concentrations, 0.0001% and .001% affected the incubation identically (3.97 to 4 days, P< 0.05), causing less delay in the incubation period as compared other remaining concentrations (0.01% to 1%) among which the egg stage (Table 25), varying from 4.55 days to 7.25 days and delaying with the advancing concentration, differed from concentration to concentration significantly (P< 0.05).

The reduction in the fecundity of the insect under the P.D.M., varied from 36.52 to 78.26% among different concentrations of the diflubenzuron but it was affected identically by the concentrations, 0.0001%. 0.001% and 0.01% of course to less extent as compare that induced by any concentration from 0.10% to 1.00% among which varying from 53.32 to 78.26% and increasing with the advancing concentration, differed with them (P< 0.05). Likewise, under the P.D.M. the net sterility, varying from 5.26 to 63.41% and increasing with the rise in the concentration differed with the concentrations of the diflubenzuron applied to pupae (P< 0.05). The per cent control over the reproduction under the influence of different concentrations of the diflubenzuron under P.D.M., varying from 39.88 to

92.03% and increasing with the advancing concentration depended on the strength of the diflubenzuron applied ($P < 0.05$).

5.4 A.b Effect of diflubenzuron on the reproduction under A.F.M. (Tables 21, 25, 29) :

Any concentration of the diflubenzuron applied earlier to parents adults through food, increased the preoviposition period ($P < 0.05$). Under A.F.M., this period varied from 3 to 3.84 days among different concentrations of this insect growth regulator and in this context, the statistical analysis revealed that the 0.0001%, 0.001% and 0.01%. concentrations affected the preoviposition period identically and likewise, 0.10%, 0.50% and 1.00% concentrations also acted as compared any of the former concentrations. Under this method of treatment, every concentration of the diflubenzuron affected the oviposition period ($P < 0.05$). As regards the influence of different concentrations of this insecticide on the duration of egg laying (the oviposition period), varying from 1.57 to 8 days and decreasing with the falling concentration, differed significantly with different concentrations of the diflubenzuron ($P < 0.05$).

Further, the treatment of adults with any strength of the diflubenzuron reduced the fecundity as compared the untreated condition ($P < 0.05$). The fecundity in response to treatment with different strengths of this insect growth regulator varied from 56.2 to 224.1% eggs/female and the analysis of variance revealed that 0.0001% and 0.001% affected the fecundity identically and that

among the concentrations from 0.01% to 1.00% the fecundity differed with the different concentrations, showing indirect proportionality to the concentration of the diflubenzuron.

The adults' treatment with any concentration orally reduced the fertility of the insect i.e. the percentage of eggs hatched per female ($P<0.05$). In response to different concentrations of the diflubenzuron applied through food, the fertility, varying from 14.8 to 80.5% and decreasing with the increasing strength depended on the concentration of the diflubenzuron ($P< 0.05$).

As regards the influence of different concentrations of the diflubenzuron under A.F.M., on the incubation period, the duration of the egg stage, varying from 4.21 to 7.88 days and prolonging with the advancing concentration, differed with the concentrations   ($P< 0.05$).

In response to adults' treatment with different concentrations of the diflubenzuron through food, the per cent reduction in fecundity, varying from 37.05 to 84.21% and exhibiting indirect proportionality to the concentration, was affected differently by the different concentrations ($P< 0.05$) but 0.0001% and 0.001% concentration reduced the fecundity almost identically. Further, the net sterility which varied from 11.54 to 83.73% among different concentrations under A.F.M., differed significantly from concentration to concentration and it also increase with increase in the concentration. Exactly in the same way, the per cent control on the reproduction in response to different concentrations for the diflubenzuron under A.F.M. varying from 44.32 to 97.44% and increasing with

the advancing concentration, differed significantly from concentration to concentration (P< 0.05).

5.4 A.c. Effects of diflubenzuron on reproduction under R.F.M. (Tables 21, 25, 29) :

The preoviposition period was affected by every concentration of the diflubenzuron as residue film (P< 0.05). In response to adults treatment with residue films of different concentrations of the diflubenzruon the preoviposition period (3.01 to 3.12 days) was affected identically by 0.0001%, 0.001% and 0.01% concentrations (P< 0.05) and likewise, it was also affected alike by 0.10, 0.50 and 1.00 per cent concentrations, of course, with more prolongation. As regards the influence of the diflubenzuron residue film on the oviposition period, the duration of egglaying was affected by every concentration of the diflubenzuron and this period, varying from 2.68 to 9.27 days among residue films of different concentrations and decreasing with the increasing concentration, differed significantly with the residue film concentrations (P< 0.05).

The fecundity (eggs/female) was reduced by residue film of any concentration of the diflubenzuron applied to the adult (P< 0.05). The fecundity varied from 110.80 to 226.6 eggs/female in response to treatment with residue film of different concentrations and appearing to decrease with the advancing concentration but the concentrations from 0.0001% to 0.01% caused almost identical reduction in fecundity (P> 0.05) but the fecundity, varying from 110.80

to 198.20 eggs/ female in response to treatment with residue films of 0.10% to 1.00% concentrations of the diflubenzuron and tending to be indirectly proportional to the concentration differed significantly with the concentrations. Any of these concentrations caused more reduction in the fecundity as compared 0.0001% or 0.001% or 0.01% concentrations. As regards of residue films of different concentrations of diflubenzuron, the fertility i.e., the per cent eggs hatched/female, varying from 38.4 to 86.5% and decreasing with the increasing concentration, differed significantly with the residue films of different concentrations of the diflubenzuron (P< 0.05).

The residue film of every concentration of the diflubenzuron increased the duration of the egg significantly (P< 0.05). The incubation period, varying from 3.86 to 6.87 days among the direct proportionality to the concentration. But statistical analysis showed that concentrations, 0.0001% and 0.001% affected the oviposition period identically (P> 0.05) and concentrations from 0.01% to 1.00% differed from 0.0001% or 0.001% concentrations in affecting this period. Among these concentrations, the oviposition period, varying from 1.72 to 5.26 days and decreasing with the increasing concentration, differed significantly from concentration to concentration (P< 0.05).

Under puapl dip method, the per cent reduction in the fecundity and the per cent sterility, varying from 36.52 to 78.26% and from 5.26 to 63.41% respectively and exhibiting direct proportionality to the concentration, differed significantly with the concentration of the diflubenzuron (P< 0.05). Further, as

regards the effect of diflubenzuron under this method of treatment on the per cent control of the reproduction, it varying from 39.88 to 92.03% and exhibiting direct proportionality to the concentration, depended significantly on the concentration ($P < 0.05$), and differed significantly with the concentration of the film ($P < 0.05$).

The response to adults' exposure to residue films of different concentrations of the diflubenzuron the per cent reduction in fecundity, varying from 36.77 to 69.88% and increasing with the advancing concentration, differed with the concentration of the residue film and exactly in the same way, the percent net sterility, varying from 4.84 to 57.8% among different residue film concentrations of the diflubenzuron and increasing with the increasing concentration, differed significantly with the residue film concentrations of the diflubenzuron ($P < 0.05$). As regards the per cent control over reproduction, it, varying from 39.90 to 86.88% among residue film concentrations of the diflubenzuron exhibiting direct proportionality to the concentration, depended on the concentration of the residue film ($P < 0.05$).

5.4 B. **Effects on penfluron on reproduction :**

Results have been presented in Tables 22, 26 & 30 and Figures 22 ,26 &30.

5.4 B.a **Effects of penfluron on reproduction under P.D.M. (Tables 22, 26, 30):**

Any concentration of the penfluron applied to pupae caused delay in sexual maturity. In response to treatment of pupa with different concentrations of

the penfluron, the peroviposition period varied from 3.14 to 3.84 days and increased with the concentration but the statistical analysis revealed that 0.0001%, 0.001%, 0.01%, 0.10% and 0.50% concentration affected this period identically and in comparison to these, 1.00 per cent concentration caused more delay in sexual maturity (P< 0.05). Any concentration of the penfluron applied to pupa affected the oviposition period (P< 0.05) which varying from 1.72 to 7.26 days among different concentrations, exhibited indirect proportionality to the concentration (P< 0.01).

5.4 B.b. Effects of penfluron on reproduction under A.F.M. (Tables 22, 26, 30 and Fig 22, 26 & 30) :

Any concentration of the penfluron applied to adult prolonged the sexual maturity. As per statistical analysis, the concentration from 0.0001 % to 0.50% among which the pre-oviposition period varied from 3.13 to 3.32 days, affected this period identically (P> 0.05) with less prolonging effect as compared to the 1.00% concentration of the penfluron with which the previposition period lasted for 3.84 days. Further, the treatment of adult orally with any concentration of this insecticide exerted significant influence on the oviposition period (P< 0.05). The oviposition period varied from 1.89 to 7.25 days among different concentrations of the penfluron administered orally and it declined with the advancing concentration. But the statistical analysis revealed that 0.0001% and 0.001% concentrations which induced an oviposition period of

7.25 to 7.64 days, affected this period identically with more prolonging effect as compared the other concentrations (0.01% to 1%) among which this period, varying from 1.89 to 5.87 days and decreasing with the increasing concentration, differed significantly with the concentrations of the penfluron applied through food (P< 0.05).

Every concentration of the penfluron administered orally, reduced the fecundity (P< 0.05). As regards the effect of different concentrations of the penfluron applied to adult through food, the number of eggs laid/female varied from 68.4 to 225.2 eggs among them, increased with the decreasing concentration. But as per statistical analysis, 0.0001% and 0.001% concentrations reduced the fecundity identically (223.8 to 225.2 eggs/female) with comparative low influence towards the reduction as compared other concentrations among which the fecundity varied from 68.4 to 181.2 eggs/female with indirect proportionality to the concentration of the penfluron. Further, every concentration of this insecticide applied to adult through food reduced the fertility. The percentage of eggs hatched per female, varying from 17.6 to 80.4% among concentrations of penfluron and exhibiting indirect proportionality to the concentration, differed significantly with different concentrations (P< 0.05).

The oral administration of different concentrations induced 37.13 to 80.79% reduction in the fecundity which differing significantly with the concentration (P< 0.05), increased with the increasing concentration. In the same

way, the net sterility, varying from 11.65 to 80.87% among females treated orally with different concentrations of this insecticide and increasing with the advancing concentration, differed from concentration to concentration significantly (P< 0.05). Further, in response to oral treatment of adult with different concentrations of the penfluron the percent control over the reproduction, varying 44.48% to 96.30% and increasing with the advancing concentration, differed from concentration to concentration (P< 0.05).

5.4 B.c Effects of penfluron on reproduction under R.F.M. (Tables 22, 26, 30) :

The residue film of any concentration of the penfluron applied to adult prolonged the preoviposition period (P< 0.05) which varied from 3.13 to 3.77 days among different concentrations, appearing to decrease with the increasing concentration but according to statistical analysis, the concentrations from 0.0001% to 0.50% acted identically in affecting the preoviposition period with less prolonging effect as compared the 1.0% concentration of this insect growth regulator (P< 0.05). Exactly in the same way every concentration of the penfluron as residue film caused change in the oviposition period. This period varied from 2.46 to 7.59 days and appeared to decrease with the increasing concentration but 0.0001% and 0.001% concentrations affected it identically (P< 0.05).

Any concentration of the penfluron as residue film reduced the fecundity considerably (P< 0.01). As regards the influence of different concentrations of the

above mentioned insecticide as residue film on the fecundity, the number of eggs laid by a female, varying from 140.6 to 260.4 eggs/female among different concentrations and decreasing with the advancing concentration, depended strongly on the concentration ($P < 0.05$). Further, every concentration of the penfluron applied as residue film lead to reduction in hatching of eggs. In response to treatment of adults with penfluron as residue films, the hatchability of eggs, varying from 42.6 to 86.6% among different concentrations and tending indirectly proportional to the concentrations was affected differently by different concentration of the residue film ($P < 0.05$). Every concentration of the penfluron applied as residue film to adults prolonged the egg-stage as compared the non-treatment condition ($P < 0.05$) and in response to adults' treatment with residue films of different concentrations of the penfluron, the incubation period varying 3.45 to 6.50 days among these concentrations and prolonging with the increasing concentrations of the residue film, depended strongly on the strength of the residue film ($P < 0.05$).

Every concentration of the penfluron administered to adults as residue film cause considerable reduction in the fecundity and the reduction in the fecundity, varying from 37.04 to 88.40% among residue films of different concentrations and increasing with the increasing concentration, was found statistically to depend on the concentration of the residue film. Likewise, the net sterility, which varied from 13.00 to 61.87% among residue films of different concentrations and appeared to increase with the advancing concentration was also affected

differently by every concentration of the residue film of this insecticide (P< 0.05). As regards the effect of the penfluron as residue films on the reproduction, the per cent control over the reproduction, varying from 30.40 to 81.55% and exhibiting direct proportionality to the concentration, depend strongly on the concentration of the residue film (P< 0.05).

5.4. C. Effects of diamino-furyl-s-triazine on reproduction :

Results have been given in Tables 23, 27, 31 and Fig 23, 27, 31.

5.4 C.a. Effects of diamino-furyl-s-triazine on reproduction under P.D.M. (Tables 23, 27, 31) :

Every concentration of the diamino-furyl-s-triazine applied earlier at the pupal stage delayed the sexual maturity (P< 0.05). In response to treatment of pupae with different concentrations of the diamino-furyl-s-triazine the preoviposition period varied from 3.0 to 3.71 days and appeared increasing with the advancing concentration but the statistical analysis revealed that the concentrations form 0.0001% to 0.50% influenced this period identically (P<0.05), causing less delay in the sexual maturity as compared 1.0% concentration (P< 0.05). Like the preoviposition period, the oviposition period was also affected significantly by every concentration of the diamino-furyl-s-triazine applied to pupa (P< 0.05). This period, varying from 2.76 to 8.23 days among different concentrations of the insecticide applied to pupae and decreasing

with the increasing concentration level, was detected to differ with the concentration of the insect growth regulator applied to pupae (P< 0.05).

Further, the female, not treated earlier at the pupal stage laid significantly more eggs than the female treated earlier at the pupal stge with any concentration of the diamino-furyl-s-triazine (P< 0.05). As regard the different concentrations of this insecticide under the pupal dip treatment on the fecundity, the number of eggs laid by a female, varied from 78 to 250 fell with the advancing concentration. But as per analysis of variance, 0.0001% and 0.001% concentrations behaved identically in affecting the fecundity with less reducing as compared any of the 0.01%, 0.10%, 0.50% and 1.0% concentrations among which the number of eggs laid/female, varying from 78 to 220 and decreasing with the advancing concentration, differed significantly from concentration to concentration (P< 0.05). Likewise the fertility of the female i.e. the percentage of hatching of eggs per female was reduced when any concentration of the above mentioned insect growth regulator was applied earlier at the pupal stage (P< 0.05) and this varying from 36.6 to 87.2% and tending the decrease with the increasing concentration, as per Chi-square test, depended on the concentration of the diamino-furyl-s-triazine applied to pupae (P< 0.05). Further, the incubation period (3.65 to 6.24 days), exhibiting direct proportionality to the concentration, also differed from concentration to concentration of the diamino-furyl-s-triazine applied to pupae (P< 0.05).

The different concentrations of the diamino-furyl-s-triazine under pupal dipping treatment caused the reduction to vary from 29.78 to 78.09% exhibiting direct proportionality to the concentration and Chi-square revealed their differential influence in reducing the fecundity and exactly in the same, the per cent sterility which varied from 4.18 to 59.78%, also differed with different concentration applied to pupae (P< 0.05). The pupal dip method reduced the reproduction significantly to the extent of 32.72 to 91.20%, being progressively effective with their increasing strength (P< 0.05).

5.4 C.b. Effects of diamino-furyl-s-triazine on reproduction under A.F.M. (Tables 23, 27, 31):

The treatment of the adults with every concentration of the diamino-furyl-s-triazine delayed the sexual maturity (P< 0.05). The preoviposition period of the orally treated adults varied from 3.0 to 3.71 days in response to different concentrations of the insect growth regulator and appeared to be directly proportional to the concentration applied but as per statistical analysis, on the basis of their delaying effect on the sexual maturity these different concentrations of the insecticide could be arranged as 0.0001%, 0.001%, 0.01%, 0.10%, 0.50% and 1.00%. All of these concentrations also affected the oviposition period which varied from 2.76 to 8.23 days among different concentrations of the diamino-furyl-s-triazine applied orally to adults and it decreased with the increasing concentration. The analysis of variance test revealed that under A.F.M., the

oviposition period depended on the concentration of the diamino-furyl-s-triazine (P< 0.05).

Further, every concentration of the above mentioned insecticide applied to adults through food caused considerable reduction in the fecundity as compared the fecundity of the untreated females(P< 0.05). In this context the results revealed that the different concentrations of this insecticide caused a female to lay 70.1 to 220 eggs which depended statistically on the strength of the insect growth regulator (P< 0.05) and decreased with the advancing concentration. Further, the female treated orally with any concentration of the diamino-furyl-s-triazine had less fertility as compared the untreated female (P< 0.05). The percentage of hatching of eggs/female varied from 19.30 to 80.30% among different concentrations, exhibiting fall with the increase in the concentration and it differed significantly with the different concentrations (P< 0.05). Furthermore, the treatment of the female with any concentration of the above mentioned insect growth regulator through food prolonged the incubation period (P< 0.05) which varied from 4 to 6.35 days in response to different concentrations and depended significantly on the concentration (P< 0.05), exhibiting increase in the egg-stage with progressively increasing concentration.

In response to female's treatment orally with different concentrations of the diamino-furyl-s-triazine, the reduction in fecundity varied from 38.20 to 80.34%, the reduction being more with higher concentrations and

the Chi-square test revealed that the per cent reduction in fecundity depended on the concentration of the insecticide (P<0.5). Further, the per cent net sterility which varied from 11.76 to 78.79% among females treated separately with different concentrations, exhibiting direct proportionality to the concentration, was detected to differ significantly with different concentrations. Likewise, the per cent control over reproduction as attribute of different concentrations of this fourth generation insecticide under adult feeding method, varying from 45.46 to 95.80% and increasing with the advancing concentration, was significantly affected by the strength of the insecticide (P<0.05).

5.4.C.c Effects of diamino-furyl-s-triazine on reproduction under R.F.M. (Tables 23, 27, 31):

The residue film of any concentration of the diamino-furyl-s-triazine to the female delayed the sexual maturity (P<0.05). But the residue film concentrations of this fourth generation insecticide from 0.0001% to 0.50%, as per statistical analysis, behaving identically in affecting the preoviposition period identically induced shorter preoviposition period (3 to 3.35 days) as compared 1.0% concentration of the residue film (3.68 days, P<0.01).

Like this period, the oviposition duration was also affected when any concentration of this insecticide was applied to the female as residue film (P<0.05). But residue films of 0.0001% and 0.001% concentrations induced statistically similar oviposition period (3.0 to 8.14 days, P> 0.05), seeing more

than that induced by residue films of higher concentrations (0.01% to 1%) of residue films among which varying from 3.0 to 6.24 days and decreasing with the increasing concentration depended strongly on the concentration of the residue film (P<0.05).

Further, every concentration of the diamino-furyl-s-triazine applied to female reduced the fecundity considerably as compared to that of the untreated female (P<0.05). The number of eggs laid by a female in response to its residue film treatment varied from 136.4 to 261.3 eggs, decreasing with increase in the concentration of the residue film of the insect growth regulator analysis of variance it differed strongly with the concentration of the residue film (P<0.05). Likewise, the percentage of eggs hatched/female was also reduced by any strength of the residue film (P<0.05). In response to treatment with residue films of different concentrations of this insecticide, the percentage of hatching of eggs/female varying from 41.4 to 87.2% and declining with the advancing concentration differed significantly from concentration to concentration (P<0.05). Likewise, residue film of every concentration prolonged the egg stage (P<0.05). The incubation period, increasing with increase in the concentration varied from 3.72 to 6 days among residue film of different concentrations and differed with the concentration of the residue film (P<0.05).

The per cent reduction in fecundity and per cent net sterility, varying from 26.60 to 61.86 and from 3.29 to 54.51% respectively and both increasing with increase in the concentration depended on the concentration of

the residue film (P<0.05). Likewise, the per cent control over reproduction, varying from 29.66 to 82.56% in response to residue film of different concentrations and being directly proportional to the concentration, differed significantly with the concentration of the residue film of the diamino-furyl-s-triazine (P<0.05).

5.4.D. Effects of benzoyl phenyl urea on reproduction :

Results have been presented in Table 24, 28, 32 and fig 24, 28, 32

5.4.D.a. Effect of benzoyl phenyl urea on reproduction under P.D.M. (Table – 24, 28, 32):

The treatment of pupae with any concentration of the benzoyl phenyl urea prolonged the pre oviposition period significantly (P<.05). In response to treatment earlier at the pupal stage with different concentrations of this insecticide, the above mentioned period varied from 2.41 to 3 days and appeared to increase with the rise in the concentration but, as per statistical analysis, the concentrations from 0.0001% to 0.10% influencing it identically, caused significantly less prolongation in it as compared the 0.50% and 1.00% concentrations which also prolonged it identically. Further, every concentration of this insecticide applied to the pupae also affected the oviposition period and, in response to different concentrations of the benzoyl phenyl urea applied as above, this period, varying from 3.50 to 8.94 days and reducing with the advancing concentration, depended on the concentration of this insect growth regulator (P<0.05).

Every concentration of the benzoyl phenyl urea applied to pupae reduced significantly both the fecundity and fertility (P<0.05) and in response to its different concentrations applied to pupae, these two, varying from 108 to 262.3 eggs/female and from 40 to 78.7% respectively and exhibiting indirect proportionality to the concentration, differed from concentration to concentration (P<0.05). However, under such treatment, all concentrations were not effective in changing the incubation period; only 0.50% and 1.00% concentrations prolonged this period significantly (P<0.05). The later been more effective then the former ((P<0.05).

In response to pupal treatment with a different concentrations of the benzoyl phenyl urea, the reduction in fecundity, net sterility and control over reproduction, varying from 26.32 to 69.66%, from 13.52 to 65.93% and from 36.30 to 86.87% respectively and all decreasing with the advancing concentration, differed significantly with different concentration (P<0.05).

5.4.D.b. Effects of benzoyl phenyl urea on reproduction under A.F.M. (Tables 24, 28, 32):

The female treated with any concentration of the benzoyl phenyl urea through food and significantly prolonged preoviposition (P<0.05) and in response to treatment with different concentrations of this insecticide applied as above, this period varied from 3.0 to 8.90 days and appeared to prolonged with the concentration but, as per statistical analysis, the concentrations from 0.0001% to 0.50% affecting

this period identically (P<0.05), caused significantly less prolongation as compared the 1.0% concentration (P<0.05). Like the preoviposition period, the oviposition period was also affected by every concentration of this insecticide, administered to the female orally (P<0.05) and in response to the female's treatment orally with different concentrations of this insecticides, this period, varying from 1.57 to 8.0 days and exhibiting indirect proportionality to the concentrations, differed significantly with these concentrations, (P<0.05).

Further, the female treatment orally with any concentration of the benzoyl phenyl urea had significantly reduced fecundity i.e. number of the eggs by a female and the fecundity i.e., the percentage of eggs hatched per female (P<0.05) and in response to the female's treatment with different concentrations as above, these two, varying from 98.7 to 245.4 eggs/female and from 31.2 to 78.6% respectively and exhibiting the indirect relationship to the concentration, differed significantly from concentration to concentration. However, the incubation period was affected significantly only by the 0.50% and 1.0% concentrations; the former (3.76 days) causing prolongation as compared the latter (4.79 days, P<0.05).

In response to the female's treatment with different strength of the benzoyl phenyl urea through food, the reduction in fecundity, net sterility and control over reproduction, varying from 31.07 to 72.28%, from 13.63 to 65.71% and from 40.46 to 90.49% respectively and reducing with the increasing concentration, differed significantly with different concentrations of the benzoyl phenyl urea (P<0.05).

5.4.D.c. Effects of benzoyl phenyl urea on reproduction under R.F.M. (Table 24,28, 32 and fig 24, 28, 32):

The residue film of any concentration of the benzoyl phenyl urea applied to the female delayed the sexual maturity significantly ($P<0.05$) and in response to the females' treatment with residue films of different concentrations of the insecticide, the preoviposition period, varying from 2.20 to 3 days, tended to prolong with the advancing concentration but, the statistical analysis revealed that the concentrations from 0.0001% to 0.50% exerting identical influence, caused significantly less prolongation in period as compared the 1.0% concentration ($P<0.05$). Similarly, the oviposition period was also affected by every concentration of this insecticide applied as residue film to the female ($P<0.05$) and in response to the female's treatment with residue films of different strengths of this insecticide this period, varying from 3.64 to 8.92 days and exhibiting direct proportionality to the concentration, differed significantly with different concentrations ($P<0.05$).

The residue film of every concentration of the benzoyl phenyl urea applied to the female reduced considerably her fecundity and fertility ($P<0.05$) and in response to the female's treatment with residue films of different concentrations of the insect growth regulator, these two, varying from 110.3 to 257.3 eggs/female and from 34.4 to 78.8% respectively and tending to decrease with the advancing concentration, depended significantly on the concentration of the insecticide.

However, the residue films of the concentrations from 0.0001% to 0.10% did not effect the incubation period significantly but the 0.50% and 1.0% residue film concentrations prolonged this period significantly, the former being more effective ($P<0.05$).

Further, the reduction in fecundity, net sterility and control over reproduction, varying from 27.72 to 69.02%, from 13.40 to 62.20% and from 37.41 to 88.39% respectively among the residue films of different concentrations and increasing with the advancing concentration, depended significantly on the strength of the residue film of this insecticide ($P<0.05$).

5.5 STERILITY EFFECT OF INSECT GROWTH REGULATORS ON SEXES:

Results have been given in Table 33 to 36 and fig. 33 to 36.

5.5.A. Sterility effects of diflubenzuron on male and female (Table 33, fig. 33):

The mating between the female of the untreated pupa and male of the treated pupa, induced far reduced fecundity (89.2 eggs/female) as compared the mating between the male and female of the untreated puape (365 eggs/female) and, it caused 53.41% net sterility, while the cross between the female of the treated pupa and male of the untreated pupa, inducing almost similar fecundity (90.4 eggs/female) to that of the above mentioned mating but it caused comparative less reduction in the

net sterility (50.44%). However, the mating when allowed between the male and female of the treated pupae, there was further reduction in fecundity (77.4 eggs/female) without significance but the net sterility (63.41%) increased by 10 to 13% as compared the above crosses.

5.5.B Sterility effect of penfluron on male and female (Table 34 & fig. 34):

The cross between the female of the untreated pupa and male of the treated pupa, resulted in far reduced fecundity (91.3 eggs/female) as compared the mating between the female and male of the untreated pupae (365 eggs.female) and it caused 52.4% net sterility, whereas the mating between the female of the treated pupa and male of the untreated pupa., inducing almost similar fecundity (94.6 eggs/female; $P<0.05$), caused 46.5% net sterility. The mating between the female and male of the treated pupae appeared to cause further reduction (83.4 eggs/female) but not significantly different from that of the above mentioned crosses ($P>0.05$). However, it certainly increased the net sterility (58.2%) by about 6 to 12% as compared these matings.

5.5 C. Sterility effects of diamino furyl-s-triazine on male and female (Table 35 & fig. 35):

The mating between the female of the untreated pupa and male of the treated pupa caused far reduction the fecundity (92.4 eggs/female) as compared the mating between the female and male of the untreated pupa (365 eggs/female) and it

led to 53.63% net sterility, whereas the cross between the female of the treated pupa and male of the untreated pupa, causing the fecundity (97.6 eggs/female) to be almost similar to that of the above mating (P>0.05) induced 45.50% net sterility. However, the mating between the male and female of the untreated pupae caused significant fall in the fecundity (78 eggs/female) as compared that of any of the above mentioned mating (P<0.05) and induced 59.78% net sterility.

5.5.D. Sterility effect of benzoyl phenyl urea on male and female (Table 36, & fig. 36):

The treated pupa's mating with the female of the untreated pupa caused great reduction in the fecundity (175.6 eggs/female) as compared the mating of the male and female of the untreated puapae (356 eggs/female) and induced 30.77 sterility but mating between the treated pupa's female and untreated pupa's male caused more fecundity (190.6 eggs/female) and induced more sterility (31.11%). However, the mating between the male and female of the treated pupae caused for more decline in the fecundity (108 eggs/female) and induced far more sterility (157.14%).

Chapter - VI

Discussion

DISCUSSION

Inducing sexual sterility by employing chemicals in large populations of insects has a promising scope in the control of abnoxious pests. The chemicals employed for the purpose, aim at controlling the reproduction by causing far reduction in the fecundity and fertility and this leads to the minimization of the population. Since the reproduction is conditioned by the accretion and development, while exploring influences of the sterility inducing chemicals (chemosterilants and insect growth regulators) on the repropotential or behaviour of pests, it is desirable to investigate their impacts on the growth and development too. Therefore, within its frame-work, this investigation has aimed at exploring biological effects of four insect growth regulators (fourth generation insecticides) namely Diflubenzuron, Penfluron, Diamino furyl-s-triazine and Benzoyl Phenyl Urea on the performance (growth, larval feeding, development and reproduction in black hairy caterpillar, Pericallia ricini Fabricius with special consideration for its sterility.

A perusal of the literature shows that the efficacy of the fourth generation insecticides depends upon the mode of their entry, and stage of the life-cycle to which these are applied. Some are more effective when applied to pupae than when applied to adults or larvae and vice-versa. The insect growth regulators induce variable biological effects: these are not equally or identically effective. Some are more effective than others in the same species and their

influence may be sex oriented. Different species exhibit different response to the same fourth generation insecticides.

As regards the influence of the insect growth regulators on the biomass accumulation in P. ricini larva, the related results have shown that every chemical considered under this investigation has potential to reduce the growth in this insect even at a very low concentration. Afifi & Knutson (1956), Chattoraj & Dwivedi (1980) and Sharma (1993) have also observed similar influence of insect growth regulators in other insects, the effect of the different concentrations of insect growth regulators on the accumulation of the biomass in the larva, which may not be graded in early larval life, becomes quite distinct in the late larva; the biomass reducing potential of fourth generation insecticide increases with the increase in the its concentration.

Furthermore, in respect of the influence of insect growth regulators on the biomass accumulation in P. ricini under different modes of their application to this insect, the related results indicate that the four chemicals tested during this investigation fall under two categories. The chemicals of the first category reduce the larval biomass almost identically from early to late larval life at a corresponding concentration under different modes of their application and those of the second category cause almost identical decline in the larval biomass at a corresponding concentration under different modes of their application only

upto the mid-larval life but thereafter, their corresponding concentration exert different biomass curtailing influence under different modes of their application. The diamino furyl-s-trizane belong to the first category and the difflubenzuron, penfluron and benzoyl phenyl urea are related to the second category.

The diflubenzuron applied by the pupal dip method reduced the biomass of the late larva more than when it is administered orally or applied as residue film; this chemosterilant's corresponding concentration is equally effective in reducing the larval biomass under the latter two modes of the treatment. Like the diflubenzuron, a concentration of the penfluron also becomes more effective in reducing the larval biomass under the pupal dip method as compared the application of the same as the residue film to the insect but the growth reducing potential of the same concentration applied orally matches to that which develops under the pupal dip treatment. However, contrary to these chemosterilants, a concentration of the benzoyl phenyl urea potent in decling the biomass of the late larva when it is administered orally than when it is applied by the pupal dip method or as residue film; with the pupal dip method it becomes more effective than as the residue film applied to the adult.

The fact that the diamino furyl-s-triazine is equally effective in reducing the accumulation of biomass in the larva under the pupal dip method, adult feeding method the residue film method and, diflubenzuron, penfluron and

benzoyl phenyl urea are not equally efficient in this under these methods of their application suggest that the former two insect growth regulators are equally translocated to the sites of their action under the above methods of their application to the insect. Since qdequate growth is an attribute of proper nutritional metabolism, it may be presumed that the above mentioned insect growth regulators interfere this aspect of physiology in P. ricini hence they reduce the accumulation of the biomass in larvae of this insect. Harper (1981) has reported that the apholate accepts amino acids as ligands, binding to NH_2 site and consequently, inhibiting formation of the linkage, it reduces the synthesis of some porteins in Diaphania nilidalis which owing to the same, exhibits poor growth. In P. ricini also, the chemicals used in this work may hinder the protein synthesis causing consequent reduction in the larval biomass but this needs confirmation.

In context of the efficiency of the insect growth regulators reducing the accumulation of the biomass in larvae, as per results of this investigation, considering concentrations from 0.0001 to 1.00 per cent the chemicals screened under this investigation may be arranged as diflubenzuron, penfluron, diamino-furyl-s-triazine and benzoyl phenyl urea.

Like the accumulation of the biomass of the larva, the acquisition of biomass in pupa and adults is also reduced by every insect growth regulator under all the three methods of treatment but these methods are not identically

effective in causing reduction in the biomass of the pupa and adults. Administering a chemical orally causes more reduction in the biomass of the above life-stages than the application of the same through the pupal dipping in P. ricini and the latter method of chemosterilant's application is more effective than its application as residue film in this respect.

Further, the results in this context reveal that there is an indirect proportionality between the biomass of these stage of life cycle and concentration of insect growth regulators. As regards the pupal biomass reducing potential of the different insect growth regulators these can be arranged as diamino furyl-s-triazine, penfluron, diflubenzuron and benzoyl phenyl urea in descending order. In this respect, in case of the male and female adults, the diaminofuryl-s-triazine and penfluron occupy the third and fourth ranks respectively in curtailing the biomass but in the female, chemicals stand at the fourth and third place respectively. These facts suggest that the biomass curtailing influence of the benzoyl phenyl urea and diflubenzuron in P. ricini depends on the sex.

Depending on their concentration, the fourth generation insecticides cause abnormal larval mortality, ranging from about 27% to 67%; this mortality mostly increases with the increase in the concentration. The oral administration of chemical usually cause more larval mortality than its application through the pupal dipping or as the residue film; the pupal dipping appears more

effective than the application as the residue film. As regards comparative effectiveness of the tested fourth generation insecticides, the results permit us to arrange them as diflubenzuron, penfluron, dimanio furyl-s-triazine and, benzoyl phenyl urea in descending order.

Besides causing abnormal mortality of larvae, depending on its concentration, every insect growth regulator also inhibits emergence of adults to considerable extent, the inhibition of the emergence under the influence of a chemosterilant may range from 33 to 53% as compared inhibition of emergence under natural condition and it decreases as there is increase in concentration of the fourth generation insecticides. Usually, the oral treatment with the chemosterilant is more effective than its application through pupal dipping or as the residue film in context of the inhibition of the emergence of the adults but the treatment with the residue film is effective as the pupal dipping method in this respect. As regards the efficacy of different fourth generation insecticides in inhibiting the emergence of the adults, the results permit us to arrange them as diflubenzuron, penfluron, diamino furyl-s-triazine and benzoyl phenyl urea in descending order.

The net morality gives the correct estimate of the mortality at post-embryonic stage (larvae and pupae) under the influence of the fourth generation insecticides because it is worked out after considering the natural mortality and therefore, it clearly indicates the toxicity of such chemicals (Abbot, 1925). The

diflubenzuron applied through pupal dipping causes 52% to 94% net mortality among its different concentrations; the mortality inducing potential of this insecticide increases with the progressing concentration. The different concentrations of this sterilizing compound under the oral administration cause mortalities at 0.0001% concentration. But when the different concentrations of diflubenzuron are applied as the residue film to the adult, the percentage of the net mortality is comparative low at every level. The penfluron comes next to the diflubenzuron in causing high to higher net mortality at different concentrations which with increase in the strength mostly increase the mortality under the pupal dip and adult feeding methods almost similarly but when it is applied as the residue film, it causes lesser net mortality at a concentration than the net mortality at the matching concentration either under pupal dip application or the oral administration and the percentage is directly proportional to the concentration. The diamino furyl-s-triazine is mostly inferior to the penfluron in causing net mortality in P. ricini. At any concentration it causes lesser net mortality than that under oral administration or pupal dipping application; the latter two methods of diamino-furyl-s-triazine applications cause mostly similar net morality at the corresponding concentrations. Like the diflubenzuron and penfluron the increase in the concentration of the diamino-furyl-s-triazine increases the percentage of the net morality under all the three methods of the treatment employed in this investigation. The benzoyl phenyl urea is the least effective in causing the net mortality. The net mortalities caused by it are almost similar at corresponding

concentrations under pupal dip and adult feeding methods but low when it is applied as the residue film. However, under every method of treatment the increase in its concentration increases the net mortality.

The results related to the net mortality provide a clear picture of comparative efficiency of fourth generation insecticides. As per these results, the screened insecticides may be arranged as diflubenzuron, penfluron, diamino-furyl-s-triazine and benzoyl phenyl area in descending order. The used insecticides are equally effective under the pupal dip method and oral administration in causing the net mortality which is relative hight to that which results from residue film treatment.

In respect of the influence of the fourth generation insecticides the duration of the larva, the results clearly show that each strength of the diflubenzuron, penfluron, diamino furly-s-triazine and benzoyl phenyl urea prolong the laraval period under every method of treatment. Generally, at low concentration 0.0001 to 0.01 the increase in the larval period is by about 3 to below 5 days but at high concentrations, this increase is much more and insecticide specific; at 0.50% concentration, the diflubenzuron, penfluron, diamino-furyl-s-triazine and benzoyl phenyl urea increase the larval period by 13.40 to 13.50 days, 9 to 10 days, 10.20 to 11.93 days and 5.80 to 6 days respectively under different modes of treatment and at one percent concentration,

they increases this period by 19.82 to 21.36 days, 18.32 to 21.92 days, 15.80 to 17.40 days, 10.10 to 12.40 days, 10.90 to 12.40 days and 8.00 to 8.50 days respectively under all methods of their application. Usually the pupal dip method and oral administration, being almost equally effective in prologing the larval duration, cause more increase in this period as compared the application of a chemical as the residue film. Further, the larval period increases generally with the increasing concentration but in some case the prolonging influence is identical at 0.0001, 0.001 and 0.01% concentrations. As regards the virulence of the tested fourth generation insecticides in increasing the larval period, these may be arranged as diflubenzuron , penfluron, diaminofuryl-s-triazine and benzoyl phenyl urea in descending order and each of these becomes the most effective under pupal dip method and, the least effective when it is applied as the residue film but its oral administration found more effective than its residue film.

Barring 0.0001% concentration, all other concentrations of every fourth generation insecticide prolong the pupal period which increases with the advancing concentration of chemicals. At higher concentrations, such as 1.0 per cent the pupal period becomes more than 1.5 times, about 2.5 times the pupal period under natural condition and this concentration becomes the most effective under natural condition and this concentration becomes the most effective under adult feeding method and the least effective if it is applied as the residue film and the duration prolonging influence figures intermediate between these. As regards

the comparative efficiency of the fourth generation insecticides in this context, these based on the results of the higher concentrations, may be arranged as diflubenzuron, penfluron, diamino furyl-s-triazine and benzoyl phenyl urea in descending order.

Contrary to the larval and pupal periods, every concentration of each insecticide reduces the longevity of the both male and female adults and reduction in life-span of the either sex increases as the concentration of insecticides increase. At higher concentrations, such as 0.50 and 1.0% the reduction in the life-span of the both male and female is much pronounced. At higher concentrations, the reduction in the male's longevity varies from 3.20 to 4.78 days, 2.56 to 5.84 days and from 5.02 to 8.04 days respectively, of course, depending on the kind of the chemical and the method of its application to the insect. At one per cent concentration, the effect of the diflubenzuron and diamino furyl-s-triazine that they reduce the male's longevity to about one-third of the natural longevity of the male. The results pertaining to the male's longevity permit us distinctly to determine the comparative potential and comparative effectiveness of methods of treatment of the fourth generation insecticide. As per these results in the context of the male's longevity reducing potential, the tested fourth genertion insecticides may be arranged as diflubenzuron, penfluron, diamino-furyl-s-triazine and benzoyl phenyl urea in declining sequence and these

become most effective when applied by the pupal dip method and, the least so when these are administered as the residue film.

Besides affecting the males longevity, a chemosterilant affects the life-span of the female too even at its lowest concentration and its longevity reducing potential progresses with the increasing concentration. In this respect, a chemosterilant is more effective under the pupal dip method as compared its administration orally or as the residue film and the oral administration produces more effect than the treatment with the residue film. Among its higher concentrations a chemosterilant cause steep decline in the females life-span. At its one per cent concentration, a chemosterilant may reduce the female's life-span to about one third of the natural longevity; some chemosterilants may reduce it to more than half the natural longevity. Depending on their longevity reducing potential, the tested insecticides may be arranged as diflubenzuron, penfluron, diamono-furyl-s-triaine and benzoyl phenyl urea in descending order.

The chemosterilants, as their name suggest are the potent compounds which sterility and consequently, aid in control of the pest population and the sterility is the manifestation of the reduction in both the fecundity and fertility (viability of eggs laid by a female) and, it depends on the stage of the life cycle (eggs, larvae, pupae and adutls). In this investigation, only pupae and adults were selected to be treated. The selection of the pupal stage is related to two facts

: (1) the pupal stage is one in which critical gonadal development takes place and, (2) in many insects, the chemosterilants applied at the pupal stage have been successful in inducing sterility to a considerable extent   (Bobaye and Carman, 1975; Codogon et. al., (1997); Chockalingam and Krishnan, 1984; Dhawan, 1991; Gupta et. al.., 1994; Kadam et. al., 1995a; Khan and Srivastava, 1988; Khan and Srivastava, 1989; Masih, 1992; Saxena and Khattri 2000; Saxena et. al., 2001).

All the fourth generation insecticides, screened against Pericallia ricini when applied to the pupal stage are effective in causing sterility even at their lowest concentration in this insect. These induce sterility by reducing the fecundity any by decreasing the viability of the eggs laid by a female. The related results in the context of the diflubenzuron reveal that the fecundity decreases with the increase in the concentration; however, concentrations from 0.0001 to 0.01 per cent reduce the fecundity identically. The results also show that under the influence of the diflubenzuron the fertility decreases distinctly with the advancing concentration and the data pertaining to the per cent reduction in fecundity and per cent net sterility confirm the above facts. Like the diflubenzuron, 0.0001 and 0.001 per cent concentration cause identical reduction in the fecundity and its' other concentration cause progressive decline in the fecundity. However, the related data on the per cent reduction in the fecundity shows clearly that there is indirect proportionality between the reduction in the fecundity and concnentration of the diamino-furyl-s-triazine. This trend is also evinced by the data relating to

the per cent caused by different concentrations of the diamino furyl – s- triazine under the pupal dip method of the treatment. Under this method of application, in case of the remaining fourth generation insecticides also, the reduction in the number of the eggs laid by a female and the hatchability of the laid eggs are distinctly concentration dependent; these decreases with the increasing concentrations of the insect growth regulators. This trend is clearly witnessed by the data on the per cent reduction in fecundity and the per cent net sterility. Under the pupal dip method at one per cent concentration the diflubenzruon and penfluron induce about more than 29-33 per cent net sterility respectively, whereas at the same concentration, the diamino furyl –s-triazine and benzoyl phenyl urea induce about 45 to 46 % net sterility. On the basis of their sterility inducing efficiency under the pupal dip method, the insect growth regulators screened against P. ricini may be arranged as diflubenzuron (63.41) diaminofuryl-s-triazne (59.28), penfluron (58.24%), and hempa (57.25%) in descending order. Apparently, the diflubenzuron and benzoyl phenyl urea are found most effective and the least effective chemosterilants under the pupal dip method of the treatment. However, contrary to our findings, Keiser et. al. (1965) have reported that the pupal stage is not a suitable stage in fruit flies for successful sterilization because a very high concentration of the chemosterilant (upto 40% or more) is required for complete sterilization of the female flies. The reports are also available in the literature that the lepidopterous insects, in general, respond poorly to the sterilizing action of the chemosterilants (Collier and Downey, 1965, 1967;

Hathway et al., 1966). Contrary to this, as per results of this investigation, P. ricini, a lepidopterous insect, responds fairly well at one per cent concentration to the chemosterilants applied to the pupal stage; with this concentration every chemosterilant induces more than 50% sterility.

Besides, the above mentioned aspects of the reproduction in P. ricini the chemicals applied through the pupal dipping method also effect the preoviposition and ovi-position period. The previposition period prolong even with 0.0001% concentration of any insecticide. This fact suggests that a fourth generation insecticide delays the sexual maturity in P.ricini. In this insect the delay in sexual maturity increases with the increasing concentration of the fourth generation insecticide. In context of the delay in sexual maturity, considering influence of one per cent concentration, the different fourth generation insecticide may be arranged as diflubenzuron, penfluron, diamino furyl-s-triazine and benzoyl phenyl urea in descending sequence. Like the preoviposition period, when applied through pupal dipping, each insecticide even at its lowest concentration (0.0001%) affects the oviposition period too and, this period decreases with the increasing concentration. Since the decreased oviposition period is associated with the decreased fecundity, this fact suggests that every insecticide retards or inhibits the oviposition.

Under the above mentioned methods of the treatment, each of the screened insect growth regulators has potential to increase the incubation period but in this respect, the effective concentration is dependent on the kind of the chemical. In case of the benzoyal phenyl urea, the concentrations from 0.0001 to 1.00 per cent do not exert influence on the incubation period. However, the remaining insecticides exert their influence even at the lowest concentration (0.0001%) and their potential in this regard increases with the increasing concentration. In case of former chemicals also, the concentrations above the effective concentration cause proportionate increase in the incubation period depending on their strength. The above facts suggest that the insect growth regulators lower the speed of the embryonic development which becomes more and more slow with the progressive increase in the strength of the insecticide.

The literature reveals that among lepidopterous insects, the oral administrations of insect growth regulators in adults has led to the adverse influences on the reproduction, i.e., it leads to the sterility with different levels of success (Young and Cox, 1965; Toppozoda et. al., 1966, Howland et. al., 1965, Flint et. al., 1968 a & b; Henneberry and Kishaba, 1966, Soto and Graves, 1967; Sharma, 1993). Our results also indicate that when these insecticides are administered orally in adults, they are able to induce the sterility which exhibits direct proportionality to their concentration but the considerabley effective concentration which causes more than forty per cent sterility differ from

insecticide to insecticide, the benzoyl phenyl urea exert such influence at 0.0001%
level and the penfluron and diamino furyl-s-triazine acquire such potential at 0.50
per cent level but the diflubenzuron does not acquire it even at the latter level.
However, at one per cent concentration all the four insect growth regulators are able
to cause very high sterility but not cent per cent. At this concentration their sterility
inducing potential differs among them and on this basis, these can be arranged as
diflubenzuron (83.73%), penfluron (80.87%), diamino furyl-s-traizne (78.79%) and
benzoyl pheynl urea (72.53%) in descending order. However, in case of all the insect
growth regulators, there is a progressive increase in the sterility with the advancing
concentrations which decrease the fecundity and fertility accordingly. As per our
results, at one per cent concentration of a chemical which induces very high sterility,
the longevity of the female P.ricini is very much reduced but contrary to this, in
Prodenia litura, the induction of complete or very high sterility does not affect the
longevity of the female. Further, in cabbage looper moths fed on 0.0001%
diflubenzuron and penfluron, only partial and low sterility is acquired. In P.ricini
also, these fourth generation insecticides are able to induce similar sterility at
0.0001% concentration. The fourth generation insecticides screened under this
investigation are able to control the reproduction in P.ricini to the extent of about 93
to 97.44% at one per cent concentration and in this respect, at one per cent
concentration the diflubenzuron is the most effective fourth generation insecticide
and benzoyl phenyl urea which exert similar influence in controlling the
reproduction, are the least effective ones under the adult feeding method.

Like the pupal dip treatment, the oral administration of the insect growth regulator also delays the sexual maturity in P.ricini and effects its oviposition period which decreases with the increase in the concentration of insecticide. However, under this method of treatment 0.0001 to 0.001% concentration of benzoyl phenyl urea are not able to affect the incubation period but their other concentrations prolong this period which exhibits a tendency towards increase with the increasing concentration. Apart from benzoyl phenyl urea every concentration of the remaining insect growth regulator increases this period which exhibits direct proportionality to their concentration.

When insect growth regulator applied as their residue film they affect previposition and oviposition periods with tendencies corresponding to those under the pupal dip and oral administration method and as the residue film, every concentration of these compounds exerts influence on these periods. Further, barring the residue films of 0.0001% and 0.001% concentrations of benzoyl phenyl urea, the residue films of other concentrations of these insecticides and residue films of every concentration of other insecticides cause prolongation in the incubation period which generally increase with the increase in the concentration of the residue film of insect growth regulator. Further, as the residue film, every concentration of each insect growth regulator is able to reduce the fecundity and fertility; benzoyl phenyl urea, usually exhibit indirect proportionality to the concentration of the residue film of every insect growth regulator employed in this investigation. Depending on their potential for causing the reduction in the fecundity and fertility, the residue films of

different concentrations of fourth generation insecticide increase the sterility proportionately and accordingly, affect the control over the reproduction in P.ricini . Except benzoyl phenyl urea the residue films of 0.0001 to 0.50 per cent concentrations of all other insect growth regulators cause sterility much below (40%) which may be reckoned as partial sterility but the residue film of one per cent concentration of each insect growth regulator causes more than fifty per cent sterility; at this concentration of the residue film benzoyl phenyl urea induce more than sixty per cent sterility.

The comparative sterilizing influence of insect growth regulators under the three methods of treatment is quite distinct at one per cent concentration. The results pertaining to the per cent sterility induced by an insect growth regulator, suggest that each strength of the diflubenzuron, penfluron and diamino furyl-s-triazine is more effective under its oral administration in adults than its application to pupae by dipping and that the residue film method causes less sterility as compared the pupal dip method but the benzoyl phenyl urea is more and equally effective with pupal dip and adult feeding methods than it is applied as the residue film to the adults. As regards the sterlilizing potential of the four insect growth regulators when applied to adults through oral administration, the results clearly reveal that barring the benzoyl phenyl urea which causes about 66% sterility, all other insect growth regulators induce more than 70% sterility and in the context of their sterilizing efficiency in P. ricini the four insect growth regulators screened against this insect

may be arranged as diflubenzuron (83.73%), penfluron (80.87%), diamino furyl –s-triazine (78.79%), and benzoyl phenyl urea (65.71%) in descending order.

In insects, the sex oriented sterilizing influence of the insect growth regulators has been reported by a good number of workers (Crystal, 1965; Paranell and Mettrick, 1969; Kaloostian, 1970; Sharma, 1993 and Saxena & Khattri (2000). This investigation also reveals the sex specific sterilizing influence of these compounds in   P. ricini too. The results pertaining to the sterility of P. ricini obtained from the crosses between the treated male and the untreated female, between the untreated male and treated female and between the treated male and the treated female are suggestive of three facts : (1) all the four insect growth regulators induce the sterility in both the sexes, (2) the cross between the treated male and female induces more sterility than that of a cross in which only one sex is treated, and (3) in inducing sterility, the insect growth regulators are differently effective in male and female. The diflubenzuron, penfluron, diamino furyl –s-triazine and benzoyl phenyl urea induce more sterility in male than in female. Among these, benzoyl phenyl urea induces about 11% sterility in the male as compared the female and the remaining insect growth regulators induce about 3 to 8% more sterility in the male in comparison to their sterilizing influence in the female P.ricini. Apparently, these insect growth regulators are male specific in this insect as reported in other insects too (Crystal, 1965; Parnell and Mettrick, 1969 and Sharma, 1993).

Chapter - VII

Summary

SUMMARY

The advances in science and technology over the fifty years have helped the economic entomologists to reveal various approaches to control the insect pests and keeping their population below economic injury level. The emphasis on the use of insecticides in pest management has now become significantly important due to its selective nature to class insecta and least toxicity to mammals. It was observed that different insecticides disturb the developmental and growth process in insects.

The insect selected for this research work was *Pericallia ricini*. It is a polyphagous insect feeds on soyabean, groundnut, castor, curcubits, banana, cotton, calotropis, sunflower, zenia, balsam, sweet potato, brinjal etc.. It is a major pest of Kharif Crop particularly in Gujarat & Rajasthan.

Since large number of insects/larvae of *Pericallia ricini* were required for different experimental work, the pest was collected locally and cultured in the laboratory on the natural diet. From these, test insect/larvae of known age and stage were taken as per experimental requirement.

Moths were maintained in glass chimneys with castor leaves. Eggs obtained from them were kept for hatching. Larvae hatched from eggs were placed on tender castor leaves in petridishes and reared on them till pupation. All possible

measures were taken to save larvae from bacterial and fungal infections. The first and second instars were reared in petridishes and from third instar to pupation they were reared in pneumatic troughs in small groups. Moths emerged from pupae were maintained in glass chimneys for oviposition. In this way the progeny of moths were reared generation after generation till the tenure of the investigation.

The insect growth regulators whose efficacy as insecticides has already been proved in different crop pests were selected for the present study. The names of insect growth regulators are **diflubenzuron, diamino-furyl-s-triazine, penfluron and benzoyl phenyl urea.**

The concentrations considered in this work included 0.0001, 0.001, 0.01, 0.10, 0.50 and 1.00 per cent. These concentrations were obtained by dissolving the desired quantity of chemical in acetone or methanol.

The insect was treated with different concentrations of chemicals used in this investigation by three methods, *pupal dip method, adult feeding method and residue film method.*

Studies were conducted experimentally under laboratory conditions. These studies were carried on under five main headings:

A) The effect of insect growth regulators on growth.

B) The effect of insect growth regulators on larval feeding.

C) The effect of insect growth regulators on development.

D) The effect of insect growth regulators on fecundity and fertility.

E) Sex specific sterility of insect growth regulators on sexes.

Effect of chemicals was studied in terms of accumulations of biomass in larva at regular intervals (5th, 10th and 15th day) and acquisition of biomass in both pupa and adults was evaluated.

Larva of the control experiment accumulated 4.30 mg biomass on the 5th days. Whereas the larval biomass on the 5th day varied from 1.67 to 3.80 mg under influence of different concentrations of different insecticides when applied by puapl dip method. By pupal dip method different chemicals at 1.00 per cent concentration showed larval biomass as diflubenzuron (1.67mg), penfluron (1.67mg) diamino furyl-s-triazine (1.68 mg) and benzoyl phenyl urea (1.82 mg).

Under adult feeding method different concentrations of insect growth regulators used in this investigation caused change in larval biomass on 5th day in comparison of control experiment (4.30 mg). under this method of treatment at one per cent concentration different insecticides showed larval biomass as diflubenzuron (1.76 mg), penfluron (1.78 mg), diamino furyl-s-triazine (1.79 mg) and benzoyl phenyl urea (1.86 mg) in ascending order.

Under residue film method, different concentrations of insect growth regulators used in this investigation caused change in larval biomass on 5th day in comparison of control experiment (4.30 mg). Under this method of treatment at one per cent concentration different chemicals showed larval biomass as diflubenzuron (1.80 mg), penfluron (1.85 mg), diamino furyl-s-triazine (1.74 mg) and benzoyl phenyl urea (2.20 mg).

On 10th day of the larval development the control larva had 22.64 mg biomass. *On the same day, under pupal dip method of treatment different* concentrations of all insect growth regulators used in this investigation influenced the larval biomass and it was varied from 6.80 mg to 15.71 mg. The biomass of the larva exhibited the tendency of decrease with increase in the concentration of insecticide (0.0001 – 1.00 per cent) on this day of development.

Under adult feeding method of treatment, on 10th day of the larval period, *every concentration of all insect growth regulators, used in this* work influenced this stage of development in comparison of control experiment. It was varied from 6.83 mg to 16.18 mg.

Under residue film method of treatment, on 10th day of the larval period, every concentration of every insecticide influenced this period in comparison of control experiment. It was varied from 6.84 mg to 16.28 mg.

The biomass of the control larva was 110.93 mg on the 15th day and it was significantly more than that of the larva on the same day under influence of any concentration of any insect growth regulator in this investigation. In response to pupal dip treatment the biomass of the larva on 15th day varied from 20.64 to 75.23 mg and it differed significantly with strength of insect growth regulator. The biomass of larva decreased with increase in the concentration of the fourth generation insecticides.

Under adult feeding method of treatment, on 15th day of development, every concentration of every insect growth regulator used in this work influenced the

growth of larva. In response to this method of treatment the biomass of the larva on 15th day varied from 21.04 mg to 76.80 mg and it differed significantly with the strength of insecticide (P<0.01).

Under residue film method of treatment, the larval biomass also influenced by every concentration of every insect growth regulator and it varied from 22.57 mg to 77.90 mg and it differed significantly with increase in the concentration of the fourth generation insecticide used in this work.

As regards the influence of the insect growth regulators on the biomass accumulation in *Pericallia ricini* larva, the related results have shown that every insecticide considered under this investigation has potential to reduce the growth in this insect even at very low concentration. In context of the efficiency of the insect growth regulators reducing the accumulation of the biomass in larva, as per results of this investigation, considering concentrations from 0.0001 to 1.00 per cent the insecticides screened under this investigation may be arranged as diflubenzuron, penfluron, diamino furyl-s-triazine and benzoyl phenyl urea.

Pupa obtained from the untreated adults acquired 152.60 mg biomass which was considerably more than that of the pupa obtained from the adults / larvae treated earlier by all methods. Weight of the pupa varied from 69.56 mg to 153.82 mg in response to different concentrations of different insect growth regulators used for treatment of pupae by dip method. Under adult feeding method of treatment, the weight of the pupa varied from 64.56 to 142.84mg in response to different

concentrations of the insecticides and it was detected to differ with the concentration and decrease with the increasing concentrations.

Under residue film method of treatment every fourth generation insecticide effected the weight of pupae of *Pericallia ricini*. The weight of the pupa varied from 73.16 mg to 153.82 mg and it was differed significantly (P<0.01).

The male obtained from the untreated pupa/adult was heavier (106.47mg) than that obtained from pupae treated by dip method with any concentration of any fourth generation insecticide used in this research study. Weight of the male varied from 48.36 to 101.86 mg in response to the pupal treatment with different concentrations of the insecticides and as per analysis of variance, the weight of the male depended on concentration of the chemical with a clear tendency to decrease with increasing concentration.

In response to adult feeding method of treatment with different concentrations of insecticides used in this work the male weighted from 44.24 mg to 96.44 mg and it appeared to decrease with increase in the concentration of the chemical.

In response to residue film method of treatment with different concentrations of insecticides, the male adults acquired biomass from 54.02 mg to 105.22 mg and it was observed to differ with the concentrations of insecticides and decrease with the increasing concentration (P<0.01).

The female obtained from untreated adults acquired more biomass (112.06mg) than that obtained from adults treated by residue film method with

different concentrations of fourth generation insecticides (p<0.01). As regards the effect of different concentrations of insecticides, the biomass accumulated by the female varied from 55.80mg to 113.62mg decreasing with the increasing concentration of the insecticide and the analysis of variance test showed it to be dependent on the concentration of the insecticide (P<0.01).

Under adult feeding method of treatment with the any concentration of every insect growth regulator used in this study, the female adult acquired the weight from 47.20mg to 101.84 mg and it was found dependent on the concentration of the insecticide (P<0.01).

Female obtained from the pupae earlier treated with any concentration of every fourth generation insecticide, acquired weight from 51.39mg to 103.63mg and it was dependent on the concentration of the insecticide (P<0.01) and it decreased with increase in the concentration of insect growth regulator.

Like the accumulation of the biomass of the larva, the acquisition of biomass in pupa and adult is also reduced by every insecticide under all the three methods of treatment but these methods are not identically effective in causing reduction in the biomass of pupa and adults.

Administering an insecticide by adult feeding method cause more reduction in the biomass of pupae & adult than the other methods of treatment. As regards the pupal biomass reducing potential of different insecticides used in this research work, these can be arranged as diamino furyl-s-triazine, penfluron, diflubenzuron and benzoyl phenyl urea in descending order. In case of adults (male

and female) all concentrations of all insecticides used in this work curtailed the weight considerably and found that the biomass curtailing influence of the benzoyl phenyl urea and diflubenzuron in *Pericallia ricini* depends on the sex.

In the larval feeding treatment, diflubenzuron, penfluron, diamino-furyl-s-triazine and benzoyl phenyl urea suppressed the rate of food consumption in treated larvae at higher concentration level but at lower level, the insect growth regulators used in this work were less effective in reduction the food and the food consumption. The insecticides suppressed the rate of consumption of food and the food digested by treated larvae was reduced with the increase in concentration level. This finding showed the inability in feeding by treated larvae.

The larvae of the adults of the untreated stock had considerably more survival (83.33 per cent) as compared those of the pupae/adults of the treated stock. In response to treatment of pupae, the survival of the larvae varied from 30.33 to 83.33 per cent decreasing with the increasing concentration of the fourth generation insecticide. Whereas that of adults treated by residue film method with any concentration acquired survival in the range between 33.33 to 83.33 per cent (P<0.01).

In response to treatment by adult feeding method, the larval survival varied from 28.33 to 81.66 per cent and found decreasing significantly with the increasing concentration of the insecticide (P<0.01).

As regards comparative effectiveness of all insect growth regulators tested in this work, the results allowed me to arrange them as diflubenzuron, penfluron, diamino furyl-s-triazine and benzoyl phenyl urea in descending order.

Further, the larva of the untreated stock grew faster than that of larva of treated stock with any concentration of any insect growth regulator by pupal dip method, adult feeding method and residue film method. As regards influence of different concentrations of the insecticides by pupal dip method, the duration of larval stage varying from 16.50 to 36.73 days whereas that of adults treated by residue film method with any concentration of any insecticide, the duration of larval stage varying from 16.78 ti 36.36 days. Also, under adult feeding treatment the larval stage varied from 16.62 to 34.82 days and observed increasing with the increasing concentration, was detected to depend on the concentration of insecticide (P<0.05).

In respect of the influence of the insecticides used in this project work, the duration of the larva, the results showed that each strength of every insect growth regulator prolong the larval period under every method of treatment. As low concentration the increase in larval period is only about 3 to 5 days but at high concentrations, the increase in larval days in much more and insecticide specific; at one per cent concentration the larval period increased by 8.00 to 21.36 days. The pupal dip method and adult feeding method, being almost equally effective in prolonging the larval duration, cause more increase in this period as compared the application of insecticides as the residue film. As regards the virulence of the tested insect growth regulators in increasing the larval period, these may be arranged as

diflubenzuron, penfluron, diamino furyl-s-triazine and benzoyl phenyl urea in descending order.

The pupa of the untreated adults had hundred per cent emergence, which was much curtailed in case of the treatment by every method of treatment with any concentration of all insecticides used in this investigation. In response to treatment by pupal dip method, the percentage of the emergence, varying from 16.66 to 66.00. In response to adult feeding treatment, the percentage of emergence was varied between 17.67 to 67.35. Further, in response to residue film method of treatment, the percentage of emergence was varied between 20.00 to 68.00 per cent and in all types of treatments it was found decreasing with the increase in the concentration of insecticide ($P<0.05$).

There was significant difference in the pupal period between the non treatment condition and the treatment situation at any strength of used insect growth regulators. The pupal period was prolonged considerably by all concentrations of all insecticides. The pupal period varied from 11.20 days to 29.72 days under pupal dip treatment. The pupal period varied from 11.22 days to 29.00 days under adult feeding method of treatment and it varied from 11.20 to 27.04 days under residue film method of treatment and found increasing with the increase in the concentration, depended significantly on the strength of the insect growth regulator ($P<0.05$).

As regards the comparative efficiency of the insect growth regulators in this context, these based on the results of the higher concentration may be

arranged on diflubenzuron , penfluron, diamino furyl-s-triazine and benzoyl phenyl urea in descending order.

Under the different methods of treatments applied in this work with different concentrations of all insecticides used in this investigation, curtailed the longevity of both male and female adults significantly as compared parent adult's non treatment ($P<0.05$). The male lived 3.44 days to 9.88 days while female lived 4.38 days to 13.98 days. It was also observed that the female lived longer than male. The life span in either sex, decreasing with the increasing concentration, differed significantly with the concentration of the fourth generation insecticides ($P<0.05$).

The results pertaining to the longevity of male and female *Pericallia ricini* permit us distinctly to determine the comparative potential and comparative effectiveness of method of treatment of insect growth regulator. As per the result in the context of longevity reducing potential in both sexes, the tested insecticides may be arranged as diflubenzuron, penfluron, diamino furyl-s-triazine and benzoyl phenyl urea in declining sequence and these become most effective when applied by the pupal dip method and, the least so when these are administered as the residue film.

The net mortality, varying from 34 to 94 percent among different concentrations of the different insecticides used in this research work when applied earlier at parent pupae stage and adult feeding method and appearing to be directly proportional to the concentrations, depended on the concentration ($P<0.05$). Under residue film method, the net mortality, varying from 32 to 92 per cent among

different concentrations of different insecticides and as per chi-square test, it differed from concentration to concentration (P<0.05).

The sexual maturity of the adult in response to treatment of pupae/adult by pupal dip, adult feeding and residue film method with any concentration of every insect growth regulator used in this investigation affected the preoviposition period, appearing to decrease with the increasing concentrations. Diflubenzuron by pupal dip method affected the preoviposition period of *Pericallia ricini* more in comparison with other insect growth regulator used in this investigation. The preoviposition period prolong even with 0.0001 per cent concentration of any insecticide. This fact suggests that every insecticide delays the sexual maturity in *Pericallia ricini*.

Every concentration of used insect growth regulator influenced the duration of oviposition period. Under pupal dip method, the oviposition period was recorded from 1.46 days to 8.94 days. While under residue film method of treatment, the oviposition period was observed between 2.46 days to 9.27 days. Every concentration of used insecticide under adult feeding method of treatment affected the oviposition period of *Pericallia ricini* and it was observed between 1.57 to 8.90 days. The analysis of variance test revealed that the oviposition period depended on the concentration of the chemical (P<0.05). Each insecticide even at lower concentration affects the oviposition period. Since the decreased oviposition period is related with the decreased fecundity, the facts suggest that every insecticide retards the oviposition.

As regard the effect of different concentrations of the insect growth regulators used in this study, applied by pupal dip method, adult feeding method and residue film method, the number of eggs laid per female was variable. It varied from 77.4 eggs to 262.4 eggs among them under pupal dip method treatment. Under adult feeding method of treatment, the number of eggs laid by per female varied form 56.2 eggs to 245.4 eggs. Under residue film method of treatment, the number of eggs laid by per female varied from 110.3 to 257.3 eggs. In all types of treatments, it was observed that the number of eggs laid/female increased with the decreasing concentration and differed significantly ($P<0.05$).

Any concentration of every insect growth regulator used in this research work caused reduction in hatchability of eggs considerably ($P<0.05$). As regards the influence of different concentrations of different insecticides on the hatchability of eggs, it varied from 33.3 per cent to 89.5 per cent under pupal dip method of treatment and decreasing with the advancing concentration, depended strongly on the concentration ($P<0.05$). Under adult feeding method of treatment the percentage of hatching varied from 14.8 to 80.5 and under residue film method of treatment the percentage of hatching ranged from 34.4 to 86.5 and tending indirectly proportional to the concentration affected differently by different concentrations of the insect growth regulator ($P<0.05$).

Every concentration of the different insect growth regulator applied by pupal dip method, adult feeding method and residue film method prolonged the egg stage as compared the non-treatment condition ($P<0.05$). In response to pupal

dip method of treatment with different concentrations of fourth generation insecticides applied in this research study, the incubation period varying from 3.12 days to 7.25 days, and prolonged with the increasing concentrations of the insecticide, depended strongly on the strength of the insecticide ($P<0.05$). Further, every concentration of the different insecticides applied by adult feeding method prolonged the incubation period (3.23 to 7.92 days) delaying with the advancing concentration of insecticide differed from concentration to concentration significantly ($P<0.05$). Also under residue film method of treatment the incubation period varied significantly (3.12 to 6.87 days) delaying with the increasing concentration of insecticide.

The insecticides used in this work exert their influence even at the lowest concentration (0.0001 per cent) and their potential in this regard increases with the advancing concentration of insecticides. The findings related with the preoviposition period, oviposition period, hatchability and incubation period suggest that the fourth generation insecticides lower the speed of the embroyonic development which becomes more and more slow with the progressive increase in the strength of the insect growth regulator.

The sterlizing influence of insect growth regulators under the different methods of treatments used in this investigation is quite distinct at one per cent concentration. The results relating to this aspect suggest that each strength of the diflubenzuron, penfluron, diaminofuryl-s-triazine and benzoyl phenyl urea is more effective under its oral administration in adults than its application to pupae by

dipping and that the residue film method cause less sterility as compared the pupal dip method. As regards the sterilizing efficiency of insect growth regulators used in this research work, they may be arranged as diflubenzruon, penfluron, diamino furyl-s-triazine and benzyol phenyl urea in descending order.

The mating between untreated female and treated (By pupal dip method) male reduced fecundity 89.2 to 175.6 eggs/female as compared the mating between untreated sex partners (356 / female), it caused reduction in hatching percentage (42.2 to 62.6). The cross between the untreated male & treated female inducing almost similar fecundity (90.4 to 190.6 eggs/female). This finding was also far reduced fecundity as compared the mating between untreated male & female. However, mating between the treated male and treated female, there was further reduction in fecundity (77.4 to 108.0 eggs/female) and the percentage of hatching of eggs was recorded between 33.3 to 40. These findings confirmed that all the four insect growth regulators induce the sterility in both sexes. All insect growth regulators induce more sterility in male than in female hence these insecticides are male specific in *Pericallia ricini*.

Chapter - VIII

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